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Assessment of (GIS) Geographic Information System Technologies for ITS Applications

Report for

Industry Canada
Aerospace and Defence Branch
235 Queen Street
Ottawa, Ontario, Canada
K1A 0H5

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Transport Canada
R&D Directorate
26-B 330 Sparks Street, Tower "C"
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March 31, 1996.

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16. Abstract
The report defines the role of GIS-T within the key component technologies for ITS applications and relates it to the current industries needs. Each need is then examined against the current Canadian capability to address it, and compared to the industry threats that exist elsewhere. Opportunities are assessed and listed along with recommendations and action plans for government and Canadian industry pursuing GIS for ITS applications.

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16. Résumé
Le rapport illustre le rôle de la géomatique appliquée à l'industrie des transports dans le cadre des Systèmes de Transport Intelligents et relate le tout aux besoins de l'industrie. Chacun des besoins est ensuite examiné par rapport aux capacités de traitement canadiennes, et compare le tout aux menaces externes de l'industrie. Les opportunités sont finalement évaluées, des recommendations sont énoncées et un plan d'action est établi pour le gouvernement et l'industrie canadienne à la poursuite de la géomatique appliquée aus Systèmes de Transports Intelligents.

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NOTE

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1. Assessment of Communications Needs and Standards for ITS
   by: A. Waltho Engineering
2. Assessment of Geographic Information Systems (GIS) Technologies for ITS
   by: Intergraph Canada
3. Assessment of Positioning and Navigation Technologies for ITS
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4. Assessment of Sensor Technologies for ITS
   by: IBI Group
5. Assessment of Display Technologies for ITS
   by: IBI Group
6. Assessment of System Integration and Intelligent Software for ITS
   by: IBI Group
7. Assessment of FM Sub-Carrier Broadcast Technology Applications for ITS
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10. Assessment of the Demand, Markets and Commercial Development of Global ITS Industry
    by: SRI Consulting
11. Strategy for the Development of an ITS Industrial Base in Canada
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1. Executive Summary

Geographic Information Systems (GIS) are the set of technologies used to collect, manage, analyze and present knowledge about areas of the earth (Dueker and Kjerne, 1988). While there have been many fields making use of this technology, it is only recently that it has been applied to Transportation. The application of GIS to transportation is now commonly known as GIS-T. Through utilizing this intelligent map base, users and managers can visualize a problem and allow the appropriate software to assist with final decisions.

Based on the world wide success of several Intelligent Digital Map data suppliers along with the corresponding technology that utilize it, GIS-T (Geographic Information Systems for Transportation) cannot be overlooked as a key component technology/Industry for ITS. Companies like Navigation Technologies (Navtech) and ETAK have made significant revenues from supplying navigational map databases to end users for many uses. These uses range from Route guidance and En-route driver information to Emergency management, Commercial Vehicle operations and incident management. As a result, the assisting technologies have flourished as well. Manufacturers of In-Vehicle systems such as Sony, Toshiba and Zexel have developed technologies that are coupled with Global Positioning Systems (GPS), to give users accurate routing information. It is also said over the next few years, this industry will grow to include real time traffic information for origin - destination planning, which will incorporate newer technologies such as the Internet and roadside communications networks.

Canada has many strengths that can be used to build an offering for GIS-T within the ITS marketplace. Our mapping expertise is unprecedented. Through having some of the most highly rated university programs in geomatics, and participating in world wide standards activities, Canada has created a world renowned talent base. Building on this expertise has resulted in the creation of comprehensive map bases throughout Canada, many of which are currently being used for applications such as Emergency Services Dispatch. Other areas that are currently being developed with GIS-T are:

- Traffic Management Centers - Using a dynamic display for traffic conditions.
- Tourist Information Applications - Incorporating tourist attraction information with mapping data can route a user from origin to destination with little hassle.
- Transit Routing - Through a GPS interface and central computer vehicles can be kept to a schedule and guided along the best possible route.

Although there is a wealth of talent available to develop a Canadian GIS-T market, the biggest weakness is the ability to build and enhance this expertise specifically for the ITS market. There are three main causes contributing to this current situation.

1. Companies wishing to pursue the data reselling market, have had trouble due to the governments crown copyright and revenue generation policies. These policies have created an environment, where in order to sell a copy of any government data, royalties must be included. This is compounded even further when multiple copyrights are needed to meet a navigable data specification. As a result, the cost of selling the data becomes very high. The United States has overcome this problem through licensing data on a "one time only" basis, eliminating the need to constantly pay money back to the crown. This has created a flourishing GIS-T data business, which has also developed core industry knowledge that can be repeated elsewhere.

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2. There is currently no regulatory body to assist with the Public / Private promotion of Canadian industry, partnerships and standards. This has lead Canadian business looking to the US for guidance on issues such as standards etc. As a result, there is no way to address issues that may be purely Canadian. Partnerships have also been the strength of some other countries, where many organizations have banded together to create complex solutions. One such example is combining data with hardware to help sell In-Vehicle terminals.

3. The last key weakness is a direct cause for the first two. The lack of government involvement to date in solving the identified issues, has caused the GIS-T market to be weak. Without the government being directly involved in helping develop the ITS market, talent cannot be enhanced locally. The data issues mentioned above are symptomatic of the shortsightedness. Revenue generation being a priority, while industry development is overlooked. There is no funding for Research and Development programs at Canadian universities, and industry organizations are not promoted. Maybe, Canada should examine what the US Federal Highways Administration (FHWA) is doing via it's participation in ITS initiatives.

With only a few hurdles to overcome, the GIS-T applications for ITS industry has great potential for Canadian companies. As the market is very dynamic with new technologies introduced constantly, an application that may seem very attractive today could be non-existent tomorrow. However, given the current talent base and expertise in existing projects, there are many opportunities that Canadians can pursue. They are:

- Systems Integration - Although Canadians have not greatly developed the core technologies such as In-Vehicle terminals or GPS Units, they do have a fair amount of experience tying them together. As a result, there is a great potential for the talented base of Canadian integrators experienced in GIS-T and other technologies, to export their knowledge to the global market.

- Emergency Management - With almost every major city in Canada using a map based Emergency dispatching system. The next logical step is towards integrating the traffic management centers into a more extensive system. This will sprout new applications for on-line road condition information, and routing for emergency and civilian vehicles to avoid congestion.

- Internet - As this technology evolves, so too does it's potential for the GIS-T and ITS marketplace. This may be a method for users to query road conditions, tourist information etc. before leaving for a destination.

- Commercial Vehicle Operations - Although most of this expertise currently comes from the US, the development of this key market is still very young. The incorporation of mapping information and GPS will play a big part in the creation of this application. It could save transportation and delivery companies millions in lost time through inaccurate routing and scheduling.

- GIS-T Data providers - As already proven in other parts of the world, where data companies have played a key role in the creation of a profitable navigable database, this opportunity can be very lucrative. Should these providers succeed, so too will be the developers of the technologies that use the information. i.e. In-Vehicle terminals, Internet providers etc.

- Standards - As mentioned previously, our knowledge of the geographic data standards is unprecedented within the GIS industry. Having been looked upon as the country with the most

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credibility in this area, we have the opportunity to play a roll in establishing the GIS-T standard.

- Tourism - As Tourism falls into Canada's top ten industries, it only makes sense that there also lie a potential opportunity for GIS-T and ITS. One of the biggest problems for tourists in a foreign city is knowing were to go. A map base that can dynamically tell you were you are and how to get to your destination would be invaluable. Having already created a map based application for tourism in Ontario, the application will guide the travelers from one destination to another through a portable hand held unit. The ability to update the units electronically will keep the information current, preventing the information from being out of date. A problem tourists have with current paper maps. Advertising could also be a contributing factor to the business case.

In order for Canada to succeed in the GIS-T for ITS applications arena, a few actions must be taken. These actions will help to open this marketplace so that potential companies may be able to buy and sell data profitably, while also creating an environment where other technologies that rely on this data may succeed. Five possible actions to be able to achieve the proper success are as follows:

1. ***Create a National Digital Road Map at an accuracy meeting ITS application needs, and have it administered through one body, with input from all the stakeholders.***

The National Road Map must be made to navigable accuracy, and cover all known roads, highways and streets, at least within major urban areas. The stakeholders will be all government agencies that utilize a street network of any kind.

This activity will require the investigation of the various sources of the data across Canada to confirm the feasibility of such a map product. This could happen as a Public/ Private venture where the end result benefits Canadian business. Recommendations should cause the least amount of impact on the current working environment for government, but should foster the development of the industry.

2. ***Create a Standard Exchange through which ITS information can be distributed nationally.***

   In addition to the initiative above, there needs to be a data standard through which the above national dataset can be administered. This activity will require a review of existing programs created for GIS-T data standards, including programs outside Canada. Other activities include:

   - Define the various organizations involved in standards development and develop a flow chart indicating the necessary linkages and interactions among the players
   - Establish a process for defining user needs and developing data standards to address these needs
   - Establish a process for doing a standards inventory and setting up a clearinghouse of existing standards, maintained by one agency. ITS Canada ?

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3. ***Recognize ITS Canada as a regulatory association, put in place to help lead the development of an ITS industry in cooperation with Governments of Canada.***

   Reestablishing ITS Canada would promote the general development of the ITS industry in Canada and help address the issues from a Canadian perspective. It can be created as a medium through which Canadian firms may operate, evolve business alliances and ensure compatibility locally and with the rest of the world. This would include establishing working groups to propose and advise on current issues for strategic planning.

4. ***The Government needs to review its data access/ownership policies and programs and assess to what degree they may hamper the quick start required for the ITS industry in Canada.***

   As established during the report, one of the largest issues impeding the development of GIS-T in the ITS marketplace, is the current data access/ownership policies within all levels of government. As there is no National Digital Road Database that has been built to navigation specifications, the ability to develop and implement applications that utilize a proper map database is impossible. This is due to the inability for all government data sources to release their portion of what could be an integral part of the overall database. As data is viewed as an asset, the crown copyright becomes necessary to ensure that some investment can be recovered and ownership maintained. Although this is an honorable approach, it currently inhibits the creation and distribution of the data needed for GIS / ITS applications. As a result, Crown Copyright and Data ownership policies should be reviewed to eliminate the barriers currently in place.

5. ***Establish a program to help the research and development of GIS-T for ITS applications.***

   Due to the fact that other countries are heavily supporting their ITS Industries through University research programs, Canada must keep up. As this industry is constantly changing, having young talent constantly researching new technologies is very important to future growth. Since Canada are already the leaders in Geomatics, there is no reason private sector companies could not become the premier developers of such related technologies, through partnerships with funded universities and colleges.

The GIS-T technology for ITS applications industry is very exciting one. GIS-T technology's glamour centers around graphics based technology that offers a simplified outlook on information. Other ITS technologies can be introduced with map so that the consumer can evaluate a situation or make a decision dynamically. As populations rise and lifestyles become faster, consumers will rely more and more on this type of technology to help them run their daily lives. Through overcoming a few hurdles, data suppliers, application developers, and other related ITS technologies will be able to thrive, keeping Canada at the competitive edge of this growing marketplace.

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2. Assessment Overview

2.1 Background

As a part of the continuing effort to ensure Canadian business remains as a world leader, Industry Canada has attempted to identify certain strategic technology areas through which they can lend support. Recently, senior management identified Intelligent Transportation Systems (ITS) as one of those technologies. In order to identify the opportunities ITS offers for Canadian Industry, a study has been commissioned with the following primary objectives:

1. To undertake an assessment of Canadian industry's capability in ITS technologies and systems.

2. To evaluate threats to Canadian Industry from other countries ITS programs.

3. To identify opportunities for Canadian Industry in providing ITS technologies and systems in Canadian and foreign markets.

4. To identify ways by which Canadian companies can compete successfully in domestic and international markets.

The objectives will be met through the following five stages:

A. Background

B. Technology Assessment

C. Market Assessment

D. National Conference

E. Industry Map

Section B: Technology Assessment, was first to be contracted to individual consultants to undertake examination in the following seven primary areas. These areas were identified key to the development of ITS related applications.

1. Communications technologies

2. GIS-T/Digital Map Technologies

3. Navigation / Location Technologies

4. Sensor Technologies

5. Display Technologies

6. On-board storage and processing Technologies - Note: The assessment of On - board storage and processing Technologies will be carried out at a later date once the details of data storage and processing for ITS applications has been established. However, it is generally agreed that the computer systems storage and processing technology is developing at a much faster pace and that there should be no problem in meeting the future ITS needs in this area.

7. System Integration and Software with Intelligent Algorithms.

Each of the assessments are to cover the following areas:

1. Description of the component technologies.
2. Current state of their technological development
3. Issues related to standards, protocols and Interfaces
4. Examination of issues related to achieving compatibility and Interoperability with US and Mexico.
5. Review future trends for the development and applications of these technologies.
6. Review of the current state of development in the US, Europe, Japan and other countries.
7. Identify companies in Canada and other countries who are suppliers of component technologies and systems in these areas.
8. Plans for the development of Canadian capability in meeting domestic needs for ITS applications and to enable Canadian companies to compete in the international market place.
9. Identification of areas of opportunities for Canadian Industry .
10. Report on the above assessment.

As a part of the overall objective, the technology assessments will be used to create the strategy to develop an ITS industrial base for Canada.

The objective of this report is to assess and define the overall marketplace specifically for the GIS-T/Digital map technologies as they pertain to ITS, and report on Canada's capability to address it. The assessment of this market has been done through a variety of different ways.

Internet Search - An exhaustive Internet search was completed in order to examine all areas inclusive to this study. Although a great amount was found pertaining to ITS, little was found relating GIS-T to ITS. What was found, is included in this report.

Site Visits - Site visits were carried out in a variety of locations across the country. A list of those sites are included throughout the report and in the appendix.

Trade Journals and Publications - Having accumulated a great number of articles on the topic of GIS for Transportation, GIS Data standards, and ITS Applications, the archives were consulted on a series of different topics included in this report.

Industry Technology Trends - As a part of the sections identifying applications and opportunities, several technology professionals were consulted in order to incorporate growing technology trends. As technology advances so quickly, it has been identified that suggestions derived from this report may be out of date even at it's publication.

University Program - As determined through the Internet search, Universities provide the largest knowledge base for all ITS applications. This report will provide a synopsis of some of those programs as they pertain to GIST and ITS technologies, with references to each individual program as a part of the final report.

Assisting Organizations - Industry and Governmental Organizations provided a great amount of data for this report. ITS America being the lead organization with ITS Canada, US Federal Highways Administration (FHWA), Japanese Digital Road Map Association (JDRMA), UK Land Ordinance and Natural Resources Canada provided a great deal of varying data.

As every effort possible effort was made to examine all aspects of GIS within the context of ITS, both time and fiscal restraints have limited the scope to that which is contained in this document. It is hoped that the information contained here can be used to further define the marketplace and business opportunities within Canada.

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2.2 Marketplace Definition

Applications for GIS-T and mapping data for ITS, could be endless based on how loosely one wants to tie the technologies together. With it, the definition of the marketplace can be very broad. The following section defined the context of the marketplace in order for us to define marketable applications in the next section.

2.2.1 Intelligent Transportation Systems - (ITS)

ITS (Intelligent Transportation Systems) can be defined as:

" The application of modern computer and communications technologies in our transportation systems, resulting in improved mobility, safety, air quality, and productivity. "

1996 - ITS Online

Intelligent Vehicle Highway Systems represent a group of technologies which are evolving as a result of the need to respond to congestion and safety problems on the world's highways systems. Although the Europe and Japan were the first to enter this marketplace, the United States has the fastest growing demand. This has been partly due to the identification of ITS as both a solution to the congestion problem without building infrastructure, and diversification of the defense industry.

As defined through ITS America, the ITS Domain can now be divided into six functional areas, supporting 29 user services. The six major functional areas can operate together or independently to make up an overall system. They are defined as:

- ATMS: Advanced Traffic Management Systems
- ATIS: Advanced Traveler Information Systems
- AVCS: Advanced Vehicle Control Systems
- CVO/AFMS: Commercial Vehicle Operations / Advanced Fleet Management Systems
- APTS: Advanced Public Transit Systems
- ARTS: Advanced Rural Transportation Systems

Having close ties with the US ITS Strategies, ITS Canada is utilizing the same functional definitions and drivers for it's ITS Industry. As with the US, diversification of the defense industry is driving factor for these technologies. Ranking third in the world for revenue generated from the Aerospace and defense industries, Canada has a significant stake within this ITS diversification. One of the areas that was identified first for Canada in 1991, was Advanced Traffic Management Systems (ATMS). Canadian ATMS activities have centered around areas with a higher population. Montreal, Toronto and Vancouver areas have invested in ATMS primarily due to the limits on new transportation development. As was identified in the US, an ATMS application could improve safety and efficiency without costly infrastructure investment. The business case was sound and simple.

Although Traffic management provided a start for ITS, recently new technologies have expanded the scope of the industry. Such technologies as Weigh-in-motion (WIM), Global Positioning Systems (GPS), Automatic Vehicle Identification (AVI), and Geographic Information Systems for Transportation (GIS-T) among others have opened up the market to provide end-user

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applications to improve efficiency and safety. Today, multiple technologies may make up one ITS solution. Of those, GIS and Mapping have become very key.

2.2.2 Geographic Information Systems - Transportation (GIS-T)

Geographic Information Systems (GIS) are the set of technologies used to collect, manage, analyze and present knowledge about areas of the earth (Dueker and Kjerne, 1988). While there have been many fields making use of this technology, it is only recently that it has been applied to Transportation. The application of GIS to transportation is now commonly known as GIS-T.

A GIS-T (Geographic Information System for Transportation) is a sophisticated computer based mapping and information retrieval system for Transportation related data.

University of Pennsylvania

The sophisticated computer based system can be broken down into three components:

- Hardware - Most GIS-T applications run on a variety of hardware platforms. They have evolved over time from Mainframe and Unix machines, to currently run on Intel based Windows platforms. Some of the software packages offer the ability to run on a terminal type hardware platform as well.
- Software is the heart of GIS-T. The capabilities range from simple map display to solving a sophisticated geographical query or routing problem.
- Data primarily consists of mapping and database information. The software uses data as it's basis for calculation, by combining the two forms to produce a result. Other pieces of data that can be used is street data (i.e. direction, turning restrictions etc.) and addressing information. This data can often be referred to as a Spatial or Geospatial Database.

Spatial/Geospatial Database

For purposes of this study, a Spatial or Geospatial (used interchangeably in this report) database may be viewed as a collection of data which have a locational component relative to the surface of the earth (e.g. latitude and longitude or grid coordinates). In the majority of cases, people in the industry equate a geospatial database to one holding graphical components (e.g. points, lines, polygons, and surfaces) which are defined by location and associated attributes. The discussion of this database may be found in section 3.3.2 which describes ITS data requirements and data types.

In the United States where the concept of GIS-T is most firmly established, the passage of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) has been the catalyst for the federal government to coordinate and fund innovative transportation improvement projects. ISTEA began to generate support for the adoption of GIS-T systems throughout the public sector by developing coordinated management systems for:

- Traffic and congestion monitoring
- Intermodal facilities Management
- Pavement and Bridge Management
- Public Safety

As a result of the emphasis on coordination of all infrastructure initiatives between all levels of government, there was encouragement by all to improve transportation network record keeping

through a technology such as GIS-T. This fact was substantiated prior to ISTEA via a 1987 NCHR program of the Transportation Research Board report: " The adaptation of Geographic Information Systems for Transportation, under the recommendation that, because of the inherent geographic nature of almost all transportation related data , GIS concepts can and should serve as basis for the coherent organization of information structures and systems across the entire range of applications." Also as a part of this report, came the recommendation of several functions that will be used to distinguish GIS-T within the larger GIS field:

- ***Editing, Displaying and Measuring base maps:*** Editing functions allow users to add or delete points, lines or polygons and to change the attributes of these features. Display functions generate thematic maps which show the attributes of selected features in a variety of symbols and colors. Measurement functions determine the length of lines and the areas of polygons.
- ***Overlay:*** This function allows two or more base maps to be displayed simultaneously. A union overlay displays all the features of two or more maps : an intersection overlay only displays the features common to all the maps.
- ***Dynamic Segmentation:*** involves the division and/or aggregation of network links into segments that are homogenous for a specified set of attributes. The segmentation is considered dynamic because it is created in response to the current attributes of the network.
- ***Linear Referencing:*** is a key component to the GIS-T environment , as it provides a method through which dynamically segmented attributes can be located. Many of the software packages today offer a number of ways to reference the data.
- ***Raster Display and Analysis:*** allows photographs and other digitized images to be incorporated into a GIS. For instance, overlays of aerial photographs with highway base maps can be used as a low cost backdrop were there is no other forms of mapping available.
- ***Routing Capabilities:*** calculate optimal routes based on minimal time paths. While this function has long been available in travel demand software, incorporation of this function into a GIS-T system reduces the need to create links to other software.

Even more recently newer technologies have been added to the base set of GIS-T related functions. Recently street addressing has become a more popular way of locating information rather than via a set geographic location. This method has proven to be a slightly cheaper way to query a location due to its requirement for less data (Street network and Addresses).

Yellow Pages

Yellow page data can take full advantage of the single line network type technology mentioned above. Yellow page information is in fact an electronic copy of the same Yellow Pages found in every phone booth in Canada. With the advent of computerized databases, companies are using information like the White and Yellow Pages for activities such as telemarketing, fundraising and refreshing subscription lists. This kind of information can also be combined with geographic data to establish ideal scenarios for retail marketing and store locations. This combined with other information such as postal and linear network data can determine distance traveled to a local store or branch, as an example. Yellow page data can be supplied via ASCII text for loading into your own database and linked to the Digital Road network through the address location.

As defined, the common link between GIS-T and ITS is Transportation. Through linking Map data with database information, an intelligent road network can be created, thus the fit within ITS. Throughout the rest of this document we will discover how GIS-T technology will fit with others to define marketable applications along with their potential success.

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2.3 Findings / Recommendations

Based on the findings of this report, GIS-T technologies are being used within many applications for ITS use. These technologies can provide a simpler user interface through which users can access information quicker and easier. This coupled with the ability to tie data to a map and utilize an intelligent algorithm to accomplish things like vehicle routing, make this technology very efficient. Incorporated with emerging technologies like the internet, information kiosks, and lower cost viewer terminals, will increase its demand through allowing users wider access to information and technologies.

Although it has been established that GIS-T technology is of valuable use to ITS practitioners, the circumstances around its deployment may also hinder it's development. As the heart of the GIS-T technology for ITS applications is data, it will also be the basis for it's success. Within many jurisdictions around the world this fact has already been identified, and measures have been taken to make this information more accessible to people who need it. As a result, development of the assisting technologies have thrived.

Although Canada has a strong talent base to work from, the lack of information standards, Crown copyright and cooperation between governments have contributed to the poor quality of information available for ITS development with GIS-T technology. If Canadian industry wishes to succeed in this growing industry, many of these hurdles must be overcome. The result will be beneficial not only to any developer or distributor of GIS related applications, but to the industry as a whole.

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3. Component Technologies

3.1 Overview

As we have defined in the previous section, GIS-T can be a very key component technology for the development of more complex ITS applications. In order to better understand how final applications that contain GIS-T can be created , we must better understand the other technologies that may apply.

As a part of the overall ITS study, it has been identified that seven key component technologies are actively being used within ITS arena. Each technology ultimately depends on the next to create the final ITS Solution. The final goal of each solution is to address the needs of the user in the context of the road system. There are four key areas that each component will address. They are the Vehicle, the User, and the Road. This section will give a brief on each component, correlate its use to GIS-T, and examine how it addresses end user requirements for ITS.

3.2 Navigation / Location Technologies

Location technologies are very key to the success of ITS applications. They are primarily used for vehicle or user related activities within the ITS context. One vehicle related application is Fleet Management. Locating a moving vehicle will help private users to better track their assets, while public uses may involve user pay scenarios or overheight and hazardous waste routing. All done on-line while the vehicle is in motion. Location technologies can also be used in applications related to the road user. A primary example for locational devices for road users is navigation. Navigation functions can include in-vehicle navigation , route guidance and even dynamic route guidance, in response to the changing conditions of the road system.

With the advent of modern GPS style locational devices, users can now locate themselves within the context of a map and guide themselves to the proper destination. Other information which can be provided through some sort of communication link will be able to bring all the applications together. GIS-T data is the technology that is always coupled very closely with locational technologies. This is due to the fact that a map provides the best interface for the user. Relative location in terms of a land feature or distance along a road, is the best way for the user to understand their position. Often applications will use a position on a map to compute things like distance traveled, proximity to a restaurant, or a specific address. Other locational applications can be combined with intelligent algorithms to calculate public transit locations and adjust schedules dynamically, or route users to areas of interest. Further applications of these technologies are discussed in the next chapter.

There is a very wide variety of locational devices available today for use with mapping data. These range from Satellite Radio Frequency systems such as (GPS), and Terrestrial RF Based positioning systems to dead reckoning and sensors for positional information. For further information on these devices please refer to assessment of Positioning and Navigation technologies for ITS applications by Dr. Edward J Krakiwsky for Industry Canada, March 1996.

3.3 Sensor Technologies

Sensor technologies are also a key component in the overall ITS context. They are primarily used to assess current information and feed it back to a control center for further actions. Sensors can assist in all aspects of ITS use. In the vehicle, On-Board applications can assess it's relative location from fixed sensors mounted in the infrastructure. Sensors aboard the vehicle can position it safely within other traffic, as well as within the infrastructure. Other pertinent out side information can also be supplied by vehicle mounted units. For the road user, the sensors can provide information about other obstacles within the infrastructure. For sensors in the road, information can be gathered for things like weather conditions, accident detection and traffic flow.

Sensor technologies can be divided into two groups:

- Infrastructure applications which include:
  - Traffic flow/incident/congestion detectors;
  - Vehicle classification sensors;
  - Vehicle emissions sensors;
  - Ambient environment sensors.

- On-Board applications which include:
  - road surface / environmental sensors;
  - longitudinal / lateral control sensors;
  - night vision sensors;
  - intersection collision avoidance sensors.

Although in-vehicle sensors have been used to determine relative location along a linear referenced roadway, the installed infrastructure is very sparse and the methods are unproven. Infrastructure sensors are the main kind used for use with GIS-T related data. They are primarily fixed in and around the road, and provide information through which mapping data can display a result. These types of sensors can detect Traffic Flow/Incidents/Congestion, Vehicle types, and Ambient Environment. Of these types only Traffic Flow/ Incidents/Congestion sensors have a direct application to maps. Information can be collected remotely through inductive loop, or video, infrared or microwave type sensors. Inductive loop is the main sensor still being used in the industry. It's reliability and accuracy is still very high, although has a high maintenance. Video, Infrared and Microwave sensors are mounted over the pavement on an overpass or sign. These systems have a few more capabilities than the loop detectors, in that some can detect vehicle type etc. Some mapping applications for this technology are used for establishing traffic flow or congestion parameters and color coding segments real time as a part of a traveler advisory system. Incidents can also be plotted with relative accuracy on a map based on approximate location, and reported along with traffic flow. Further example of this technology are discussed in section 3. For further information on Sensor technologies please refer to the Sensor Technologies Assessment Report produced by the IBI Group for Industry Canada, March 1996.

3.4 Software with Intelligent Algorithms

As will be discussed further in section three, the 1995 National ITS Program Plan has identified 29 separate ITS user services, which have been bundled into seven specific areas, as prime service provided to end users. Of the twenty-nine services, they all require some sort of software to process a desired output. In terms of the key components, there are also software algorithms to process information for the vehicle, the user and road based on input from all sources.

The intelligent software takes input from several sources including sensors, human operators, locational devices and processes the information through one or more algorithms to produce ITS outputs ranging from modified Map data output to control of the vehicle. Of any application, there may be a multitude of algorithms used to produce a final output. Using modern parallel processing methods, combined output from different algorithms the user can produce a map based answer in a hurry. This is a significant improvement over older single processor technologies where the sophistication of these type of algorithms were impractical, due to the inordinate amount of time required to create a result.

Generally, intelligent software algorithms can be executed by a field controller, the system central computer, or the vehicles on-board computer. A single system may include one or all of these locations. Due to the display power it takes to use GIS-T related data, computational time is usually done on either a vehicle's on-board computer or in the system's central computer (More power).

Algorithms used with GIS-T technology can use a multitude of modern features to compute the final result. They are:

- Fuzzy Logic - An algorithm that can handle constant change to reflect up-to-date conditions. i.e. a route that can change based on traffic conditions.
- Expert Systems - An algorithm that uses a multitude of problem solving techniques based on known expert information. i.e. Establishing a route based on a multitude of criteria like gas mileage, height of vehicle, known bridge heights, pavement capacity, vehicle weight and allowable driving time. Spatial features can also be incorporated in a GIS-T context for "vicinity" and "relative to" calculations.
- Neural Networks - An algorithm that uses known statistics to calculate probable patterns. I.e. A selected route based on historical congestion and accident patterns.
- other artificial Intelligence techniques.

Software algorithms are the heart and soul of the GIS-T technology. Maps and information attached to the maps, cannot make an end solution unless there is an intelligent algorithm behind it. Although there is many algorithms behind making a GIS-T application work, the routing algorithm is the most widely used. Utilizing some of the assisting algorithms mentioned above there are many applications for routing. One simple application may be the path to nearest McDonalds. This will require a GPS receiver unit with an GIS-T vicinity map (within 5KM) to establish the current location. The algorithm would then act with the known streetline information ,and establish a route to the nearest location. As mentioned earlier, other information can also be combined from other sources such as road side sensors to make more complex decisions. More applications can be defined in the next section.

Although there are many algorithms that can be applied to ITS, no two are the same. It is this area of ITS where innovative technologies will either make or break company investing in the GIS-T for ITS business. As the technologies become more complex, the development of Intelligent algorithms for ITS applications will be key to the growth of this Industry. For more information on intelligent algorithms please refer to the Industry Canada report on the assessment of Systems Integration and Intelligent Software for ITS, prepared by the IBI group, June 1996.

3.5 Display Technologies

There are three categories of displays used within ITS applications. Again they follow the three primary areas for ITS The vehicle, the user and the road. They are, In-Vehicle displays, Control Center Displays and Roadway Displays. Of these displays, both In-Vehicle and Control Center are

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ultimately for the user. Of these, this section will only discuss In-Vehicle and Control Center displays due to their relevance to GIS-T.

Control Centers

Displays for Control centers can be divided down into three types which are usually in combination with one another. They are:

- CCTV Monitors
- Large screen projection units
- High resolution graphics

Of these units CCTV monitors and large screen projection units are the focal point of the control room. These units are often placed in combination for maximum viewing comfort. There are three main requirements for these type units. They are:

- Display units should be compatible with the video and graphic images generated by related subsystems. Parameters include resolution, and video/graphics image standard formats;
- Displays units be of appropriate size and should be placed where ergonomically feasible;
- The display system configuration should provide flexibility for expansion and upgrade.

The system architecture is usually handled through a series of video cables distributed through a switch box of some sort attached to all the display devices. The main displays within the current control room configuration are the video wall, Large screen projection unit, and operator resolution graphics. The graphical images are generated by the central computer and are routed to high resolution workstation monitors or the large screen projection units. Video walls are fixed with constant images being displayed by their corresponding fix mounted cameras. Operators have the capability of switching the images to any available display device via a control switch keypad or video switch keypad. An example would be if the operator observed an incident on the video wall he could display it on the large screen and simultaneously locate it on the map on his screen. Once completed, the large screen could move back to an overview of the network displayed as a map.

There are various types of units used for the display of images within the control room. They are:

Front Projection Units - These units are often ceiling mounted and based on the (Red, Green blue) RGB projection principle. Units can display a large image over wider area. Older units had only the ability to handled certain types of inputs, that resulted in lower resolutions and poorer images. The latest from the likes of Electrohome provide a crisper image.

Rear Projection Units - These units follow very closely with the principle define in the front projection units. They are enclosed into a single unit making it much more compact. The projection unit employs a fresnel-lenticular image surface which acts as a lens to narrow the path of the light from the projection to the image surface. The result is an increase in image brightness. Image surfaces range from 760 X 1020mm to 1900 X 2550mm. Image resolution can be displayed as high as 1280 X 1024.

Liquid Light Valve Projection - Liquid Light valve technology has been refined over a number of years. It operates in manner that is analogous to a standard film projector. A high intensity projector lamp produces light which is directed through a light valve assembly which modulates the projected image into the desired image. The image is then focused on the projection screen

using a single optical lens. These projectors are originally designed for showing NTSC and PAL standard television images and not high resolution graphics.

LCD Light Valve Projection - These units are very similar in architecture tot the Liquid Light valve projection units, with the fundamental difference being the LCD panel. These units are usually not suitable for High resolution graphics and can increase in price substantially the larger the unit. Again, these units are designed primarily for NTSC or PAL video. They also may be susceptible to image degradation based on higher ambient light conditions.

Projector Cube - This technology consists of a fully enclosed video projector and a relatively small rear projection screen. These units are 900 to 1200mm deep and are designed to be stacked on top of each other in order to create a large display surface. Resolution is comparable to VGA type graphics . The brighter display may be of advantage under higher ambient light conditions, however higher costs are associated with the controller system than with some of the other units.

Projection Wall - This display technology is similar to the projection cube. The significant difference is that the individual projection devices are not enclosed in a housing with their respective rear projection screens; rather, all of the screens and all of the projection devices are housed in a purpose built structure. Generally, the individual screen elements are slightly larger than those in a projection cube and therefore, require that the projection devices be located a greater distance away.

Monitor Wall - this type of display involves assembling a group of CRT monitors together to form a wall. Although similar in concept to the projector cube, the units works better with individual CLCTV pictures than overall graphics images. Processors are however available to display a single video image across the matrix of individual monitors.

Examples - One example of a control room is the Integrated Traffic Control Centre in Toronto, Ontario is a representative of a retrofit of advanced display technologies into the existing building envelope. The control room utilizes compact standalone rear projection units, combined with a video monitor wall and high resolution graphic operator workstations. In this case, the individual user terminals handle the map related data. In other centers there is a link to the static road network outlining accident locations, areas of congestion and construction sites.

In-Vehicle Displays and Portable Units

In-vehicle and portable displays provide information to the user about things like en-route driver information , route guidance, traveler and tourist information. In a commercial sense, information can be transmitted and received for permitting and emergency services routing purposes in-vehicle. Portable units generally work on static data as an informational source.

Within the scope of ITS, a variety of application areas such as Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Public Transportation (APTS), and Advanced Vehicle Control Systems (AVCS) utilize an assortment of Available In-Vehicle display technology.

In vehicle and portable displays should be capable of fulfilling the following functionality:

- The displays should not pose a distraction to vehicle operators and consequently should adhere to safety standards.
- The display systems should be flexible in order to support new services and display techniques as they become available.

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- The display devices should be able to interface to a variety of mobile communication media (GPS, Microwave, infrared, AM.FM Broadcast, and mobile cellular)
- The display devices should use the latest technology to ensure as simple a user-interface as possible, adhering to known standards. Map data being one of the simplest ways of reviewing results.

The system architecture for In-Vehicle display systems are usually dependent on the nature of the application that it is being used for. Often these devices may require more external interfaces as a part of the on-board application. An example of the typical configuration may include an interface to a CDROM for mapping or yellow page data, with other links to GPS receivers and/or On-board sensors to detect roadside beacons. Most ITS programs are integrating on-board systems with vehicle -to-roadside communications to provide real-time, location/direction specific information to the motorist.

There are various type of technology used for In-vehicle and portable displays. They usually fall under Liquid Crystal displays (LCD), CRT, LED for both types, while HUD (Heads Up display) and Digitized /Synthesized voice are essential for in-car applications. The units themselves may range from Non-graphic, No Input terminals to full graphics, PC like Mobile Data Terminals that have the option to be removed from the vehicle for out-of-car portable activities.

Of the displays mentioned, only LCD and CRT displays can accommodate a map data display, with CRT providing the highest resolution. However, recent changes in LCD technology now can give a far higher resolution for graphics in a far more compact unit.

LED are generally used in older ITS applications like Public transit systems where scheduling information is conveyed via textual type information. Newer system are moving in the LCD laptop style direction.

HUD and Synthesized Voice will assist the LCD and/or CRT displays with things like directions for navigation/route guidance applications. They also provide minimal impact or distractions to the driver throughout this process. This is an issue identified during the Japanese implementation of in-vehicle map displays. Safety became an important issue for navigation type applications.

Some example applications of In-Vehicle display systems that are being used for navigation and Traveler advisory purposes: In Japan, SONY has an installed base of over 5,000 in-vehicle navigation systems using CDROM map technology and CRT displays. In Europe, the Siemens Euroscout route guidance system uses LCD technology to provide mapping and tabular directions to the motorist. The UK uses LCD's to show a simplified presentation of the road network color coded to traffic volumes.

The protocols for these display units can be broken down into two sections, data formats and equipment interfaces. Currently, there are standards for this being investigated by many different bodies. For electronic information, the standard protocol for the Control center is NTSC. PAL and SECAM formats are also very prevalent. As this is the standards for Video, often there is problems integrating higher resolution graphics, since it occurs at a higher scan rate than the average video signal, an issue when it comes to GIS-T applications. This signal is often proprietary to the manufacturers of the CPUs. For In-vehicle systems, information can be accepted in a variety of formats via the RS232 connector. These interfaces are often changing and available through the manufacturer. For further information on the assessment of display technologies for ITS applications, refer to the IBI Report prepared for Industry Canada, June 1996.

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3.6 Internet

The Internet over the next few years will play a key role in many computer related applications across many spectrums. ITS will likely be no exception. The Internet's strength is through it's ability to disseminate all types of information. As it is now becoming widely accepted by all data providers as the medium of choice, the internet will supplement the ability to transfer information to and from the road user. It is not known yet whether there is any benefits to the vehicle or to the road via this medium, but only time will tell as this component technology evolves.

Given that the internet could provide a better means for information dissemination, it should accomplish the following;

- Provide a better means to get information to the road users via a simplified user interface
- Have the ability to transfer information from it's static network to a remote user.
- Be able to provide a link to intelligent processing and communicate back results.
- Be able to link to other ITS component technologies like Sensors, GPS and Display technologies.

Some of the Benefits / Limitations for this technology are:

- Reduces the requirement for on-board processing.
- Has links to a wider range of information.
- Provides medium through which subscribers can make use of real-time information, like traffic management.
- May be slow for remote Communication
- May require a more costly viewing device due to its processing and communications requirements.
- Current technology is based on raster type data. Vector information interfaces are evolving as this report is being written.

The technologies that make the Internet component involve a display device, a browser and a way to communication back into the network.

Currently the hardware required is a PC based solution containing some sort of communications card. Currently, the makers of the traditional Mobile data terminals are offering more intelligent type terminals that are mountable within the vehicle. These will have the ability to handle internet access, as they currently access information for things like crime records etc.

The medium through which information is queried and retrieved is called "The Browser". Browsers work on the principle of call and retrieve. They do not remain on line throughout the process. Historical queries can be kept in memory so that should information be required on a back query be required there will be no need to recommunicate. Browsers view information that is in the Hypertext Markup Language (HTML). HTML can be written using any number of word processors or special editors. Some browsers have the ability to interpret an item on a map as having more information associated with it. An example would be a restaurant that when you point and click at it, it brings up the menu. In the future, browsers will have the ability to apply an algorithm to information received and be able to come up with a further result.

The Internet contains two kinds of users, the user and service provider. The user only needs access to the internet through a web service provider. Usually this is done by the user

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communicating to the central web server, which is owned by a service provider, through his / her modem on a computer. The web service provider provides the link to "The Net", a location for the user to browse from. Communications for the internet are currently done through a central web server, which acts as the hub to the internet. The local phone service provider can provide a connection from your web server to the internet.

Some examples of the use of the Internet are already underway in Boston and California.

- In California, the Department of Transportation (Caltrans) has introduced a web site that allows users to view up-to-the-minute traffic information collected via their ATMS. A map is color coded according to the congestion level. The mapping is based on district, so that user only has to query the district he / she is interested in. The internet location is http://www.scubed.com/caltrans/
- In the Boston area a private firm has started up a service via the internet to advise travelers of any current incidents along the roadways.

As mentioned earlier, the Internet's biggest advantage is the link to the largest depository of information of any type. In the future, as tools like the programming language JAVA become more available an ITS user may be able to access Tourist information from one provider, Traffic data from another, and provide them together with a service provider or routing engine on the network, to get the best possible directions to a specific attraction. The Internet opens up a multitude of opportunities for both public and private sector firms wishing to participate in ITS while offering the end-user the most accurate and cost effective service possible.

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4. ITS Industry Needs for GIS-T

In order to assess this industry we must first define what the needs are to become successful. As in the definition of GIS-T, the needs for this component of ITS can be broken down into three pieces, Geographic data for Transportation, Hardware and Software Technologies. Hardware will not be discussed in this section, as it will be covered off as a part of the industry report on display devices. Software Technologies and GIS- T Data are discussed in further detail below.

4.1 Functional Requirements

Based on several definitions, the following requirements will be able to address the needs of GIS-T for ITS related applications for navigable purposes:

- Have the ability to accept mapping data from any system for information updating purposes.
- Have the ability to query locational data, like an address, and be able to display it geographically.
- Have the ability to create a linear based reference for any attached database information or address.
- Provide the ability to assign road characteristics to a linear feature within the digital map (i.e. direction of traffic, turning restrictions etc.)
- Be able to guide a user from their present location to one known through the attached database, geographically.
- Have the ability to integrate other pieces of geographical data, such as Aerial Photography, Cadastral (Lot Data), Topography, Boundaries etc.

4.2 Software Technologies

4.2.1 GIS-T Software including Intelligent Algorithms

The software requirements for GIS-T can cover a wide range of functions. These functions may range from the entry of digital mapping data to the detailed routing of multiple vehicles based on multiple electronic inputs from various sources (i.e. Sensors and GPS locations). No matter what the function, the GIST software will provide an output in terms of a geospatial map. Some of the basic functional needs for GIS-T software as they pertain to ITS applications may be defined as the following:

- Intelligent Routing - Having the ability to plan the route from one location to the next.
- Map Display - Displaying a map relative to a known position.
- Location Query- Ability to locate a point on map given a known coordinate via X, Y or Latitude, Longitude.
- Map Input - Ability to enter the map from a given source.
- Intelligent Segments for advanced applications - Ability to attached advanced information such as direction and turn restrictions for advanced applications.
- Address matching - Ability to locate a point on map according to location.

For more information see the applications defined in Section 3.4.

4.2.2 Database Technologies

Database technologies within the GIS-T context, can be defined as the information required to locate a point on a map, or solve a complex problem. This information may reside in several formats and have several levels of intelligence depending on the application and the platform that they are performed on. The technologies that house database information come in various levels of sophistication. These levels range from a simple ASCII tabular database to a relational style, where information can be indexed and relationships built for the faster assessment and retrieval of data. As speed is essential for the algorithms assessing the data, the more advanced the storage and retrieval software the better.

4.3 Data Requirements and Issues

In this increasingly "digital world" and information society, an increasing awareness has developed on the need for appropriate data to meet application needs. More often than not, the cost of creating and maintaining digital databases is the largest cost of developing a computerized system of anything - ITS is no exception. In addition to cost and time issues, data has many difficult issues which are both technical and institutional (e.g. policy). This section will provide a high level view of some of the more significant issues associated with data required for ITS applications.

4.3.1 Data Types

For many ITS applications, the types of data required may described as follows:

Geospatial (Geo-Referenced) Graphic/Mapping Data

Geospatial graphic/mapping data refers to data which has a location component referenced to a common georeferencing system (e.g. latitude and longitude to describe location on earth's surface). For use with GIS-T technology, this graphic data is usually classified as "vector" data (e.g. a single line denoting a road segment) as opposed to "raster" data (e.g. road segment comprised as a series of dots). The vector data class allows the user to attach descriptive (attribute) data and carry out complex analyses.

The role of geospatial graphic/mapping data for ITS can be summarized as providing a geographically referenced visual and mathematically consistent base for ITS applications (e.g. navigation or fleet management). It also provides the foundation database for allowing mathematical analyses to be undertaken (e.g. routing for emergency services).

Non-Graphic Attribute Data

Non-graphic attribute data refers to data which provides descriptive details regarding the graphics they are linked with. This type of data is found in text, numeric or a combined alpha-numeric form. More often than not, this data is usually stored within a relational database (e.g. a series of data tables related to each other) and having individual records linked to the geospatial graphics/mapping (e.g. road segment: type, owner, 1st maintenance date etc.).

Attribute data has a significant role to play in ITS applications, since they provide the qualitative information about the graphics. This allows users to query the application based on one or more qualitative parameters to yield a database result (e.g. illustrate one way streets and locations of traffic accidents from 1990 to present). The combination of graphic data and associated attribute

data allows a great deal of analyses to be done by user or by system algorithms (e.g. navigation: provide the directions from point A to point B).

Metadata

Metadata can be described as data about data. Metadata is descriptive data about either data sets (e.g. total road network is current to 1994) or a single data element (e.g. road segment is positionally accurate to 1m). Metadata allows user to assess whether or not the data available is suitable for the project/activity being undertaken. It is also very important when information is gathered from many different sources. Metadata ensures that the integrity of the information is maintained, a very important issue in a competitive data selling environment.

4.3.2 Data Issues - Quality, Integration, and Inter-Operability

ITS can utilize a combination of several technologies with many different sets of geospatial and attribute data. With the importance that data plays in ITS applications, it is important to appreciate that ITS data requirements can yield a range of issues which include data access, data quality, data integration and inter-operability among various systems. These may be characterized as follows:

Data Access

The issue of access to data and data ownership has become a real stumbling block to many industrial sectors that require government data. Government ownership of this data is defined by crown copyright in combination with the offsetting "freedom of information" legislation at provincial and federal governments. Many recent government initiatives (i.e. last several years) has viewed data as a new revenue source which has, in many cases, created a less than ideal environment for private sector business development. The issue of data access and value of data has currently not been resolved and this situation will act as an impediment to moving some ITS applications forward (e.g. navigation).

Data Quality

The need to determine the quality of digital data is essential to ensure the user of the data can make a judgment on the suitability of the data for the user's application. The need to know data quality often relates to risk management (i.e. minimizing liability in decision making). An example for ITS could be emergency services using a digital street network that doesn't contain recent new roads and the emergency crews have no directions to an incident. Metadata (data about data) provides a variety of qualitative information pertaining to specific data sets (e.g. currency, locational accuracy). Currently, there is no consistency in this area with differing standards/guidelines for federal and provincial data sets as well as no Metadata available for many data sets which ITS applications may require.

Integration of Data

Data requirements for ITS applications can be as diverse as the applications themselves. In many cases, the applications will require data from several different sources and conceivably from systems with different data formats. The ability to efficiently acquire and integrate data from different sources is an imperative. In many cases currently, the "integration" of data is accomplished by brute force or by re-creating the information - the need for efficiency is an ongoing issue that may impact on ITS applications.

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Inter-Operability of Data

Interoperability is often sited as a hardware/software need but it also applies to data. As opposed to data format for integration, the need for inter-operability of data sets on multiple platforms and maintained with multiple software systems requires that two issues be resolved: semantics and data structures. The issue of semantics requires that some common naming convention is followed for ITS related data (e.g. define as road, roadway .....). Data structures within an "open architecture" is the goal of a geomatics industry initiative called "Open GIS. Once again the issues of semantics and data structure are an ongoing industry issue that will certainly have an impact on ITS applications and business development.

4.3.3 *The Need for Data and Related Standards for ITS Applications*

The previous section defined a series of data related issues, which indicates that the ITS business sector in cooperation with government, needs to develop and implement a series of data standards and related policies.

Need Linkages among Hierarchy of Standards Development Organizations

There are many existing standards and standards development organizations that range from municipalities to provincial and federal governments as well as industry organizations and the International Standards Organization (ISO). In addition, there are numerous sector specific standards development (e.g. TAC) which may overlap one another and produce different standards for the same/similar data sets created by different agencies. This matrix of government layers and sectors needs to create and maintain both vertical and horizontal linkages among all those contributing to the development of data standards and policies.

Standardization Required to Fast-Track Industry Development

In any initiative to support a business sector, it is essential to provide the foundation and proper operating environment to optimize industry growth. One primary component is a focus on the issue of industry standards (e.g. data, nomenclature, policies, etc.). The TAC GIS-T data standards is an excellent start to assessing and developing standards required for ITS. Standardization should be a priority, or the sector will be hampered by the scenario of trying to fit the square peg in the round hole. This will also eliminate the problems of fitting other technologies together with both GIS-T technology and data.

Coordination and Cooperation Required in Data Standards and Policy Development

Experience has shown us that in the past a great deal of duplication and wasted resources were thrown into "re-inventing the wheel". Limited resources do not allow for duplication of efforts. In fact, some late starting sector strategies benefit from learning from those before and using their results as a framework for verifying that the sector needs are being addressed by existing standards. Unfortunately, what is commonly found is the existence of multiple standards for the same basic data set - a prime example of this is the centre-line road network; it is estimated that there exist between 6 to 10 different standards in Canada alone (excluding the U.S., other national standards, and ISO standards (TC 204 - Transport Information and Control Systems; TC 211 - Geographic Information/Geomatics). It is considered essential that all stakeholders using the data sets required by ITS applications should form part of the group process to develop/review/endorse common standards needs. Coordination and cooperation must be inherent in any modus operandi for moving forward any sector initiative.

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4.4 Applications

To date, the needs for Mapping information has been very limited within the ITS arena. It was only recently, when a Map display was integrated as a part of the Traffic Management Centers TMCs, that GIS-T data has become more widely accepted as a key decision support tool. This introduction has not only led to many TMCs to adopting the technology as a part of their main display to be able to visualize the BIG picture. Minneapolis TMC uses a map display to show the complete network along with the level of service as part of their main displays. It has been said by many integrators and users of ITS that as the technologies become more sophisticated, the movement to simpler Graphical Users Interfaces and Map displays for all applications, will increase.

This section will discuss the Industry needs in term of applications either currently in operation, being researched, and future uses of GIS-T technology within the ITS marketplace. The section is broken down into the seven functional areas, supporting 29 user services as defined by the recent U.S Draft National ITS program Plan. Each of the seven sections is defined as an ITS Domain which have been assembled based on applications with similar technological functions. In most of the cases these functions overlap through the use of the technology and Information. In a lot of the cases, GIS-T is the technology that binds them together. They are summarized in the table below:

Table 1.0

BUNDLE	USER SERVICES	GIS-T REQUIREMENT?
Travel and Traffic Management	En-route Driver Information	Yes
	Traffic control	Yes
	Traveler services information	Yes
	Route Guidance	Yes
	Incident Management	Yes
	Emissions testing and mitigation	No
Public Transportation Management	Public transportation management	Yes
	En-route transit information	Yes
	Personalized public transit	No
	Public Safety Security	Yes
Advanced vehicle safety systems	longitudinal collision avoidance	No
	Lateral collision avoidance	No
	Vision enhancement for crash avoidance	No
	Safety readiness	No
	Precrash restraint deployment	No
	Automated vehicle operation	No
Emergency Management	Emergency notification and personal security	Yes
	Emergency vehicle management	Yes
Commercial vehicle operations	Commercial vehicle electronic clearance	No
	Automated roadside safety inspection	Yes

	On-Board safety monitoring	No
	Commercial vehicle administrative processes	Yes
	Hazardous material incident response	Yes
	Commercial fleet management	Yes
Transportation Demand Management	Pre-trip Travel information	Yes
	Ride-Matching and reservation	No
	Travel demand management	Yes
Electronic Payment	Electronic payment services	No

Based on this definition of ITS, the following sections will introduce some of the areas were GIS-T can be used to develop ITS applications. Each application area will be categorized and described with a functional requirement , GIS-T technologies associated with the area, and examples of their use. For further information or contacts for each application area, please refer to Appendix F - Technology Contacts.

4.4.1 Travel and Traffic Management

En-route driver information
Traffic control
Traveler services information
Route Guidance
Incident Management
Emissions testing and mitigation

Within the ITS context, the need for GIS-T related products is very significant. There are six key applications of this technology within the Traveler and Traffic Management area:

- En-route driver information - This function provides the link to the TMC and updates drivers via various technologies about local conditions and possible methods of avoidance.
- Traffic Surveillance and Control - Collection of real-time traffic data and area-wide surveillance and detection, tied to the integrated management of various functions including demand management, toll collection, and ramp metering.
- Traveler Services Information - Information provided to the Traveler on a number of topics (Travel times, Best transportation mode, tourist sites etc.) by a variety of means (in-Vehicle displays, Kiosks etc.).
- Route Guidance - Options created via the TMC include Route Guidance as an option to avoid Traffic Congestion or any other delay.
- Incident Management - As a part of the TMC's primary operation, this function includes identification, logging and the development of a strategy to address the incident. This includes integration to other organizations as Police, Emergency Medical and Fire for Dispatching.

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En-route Driver Information

En-Route driver information covers the ability to provide a driver with the appropriate information to avoid congestion. More on this as it pertains to GIS-T is explained below under Traveler services information.

Traffic Surveillance and Control

Traffic Controls systems primary purpose is to Control Traffic. This can be done via several different ways. Within the ITS context, some of the most common ways are, adaptive signal control, ramp metering for highways, Transit or emergency services preferential treatment, and lane usage control. Route diversion can be accomplished via the Traveler Services Information system or ATIS interface.

The Map component within Traffic Control is used to display items like restricted lanes, color coding for traffic volumes, incident locations and possible diversion routes. The map provides a much clearer advisory interface for the Traffic Control Center to summarize the situation.

Although most of the information needed for the TMC will be obtained via fixed location sensors and video cameras, both transit and commercial vehicles have been optioned as possible way to collect data. As most of these vehicles now or will be, in the future be using GPS as a part of their own Commercial Vehicle Operations, there is a potential application to use maps to orient the information obtained from these informants.

A similar application has been adapted as a part of Operational tests on the TravTek project in Orlando, Florida. By taking locational information from the vehicle between two locations and fusing it with other incoming data sources, an overall travel time can be calculated. The result is then transmitted to the car for routing computations, as a part of the on-board ATIS.

Traveler Services Information

Also known as Advanced Traveler Information Systems (ATIS) this component offers the traveler either static data such as address for points of interest, or up to the minute data on traffic conditions. This information has been implemented for use through a variety of different sources, Public Kiosk, In-Vehicle terminals and recently the World Wide Web (Internet). Although this information can be made available in a tabular format, the biggest demand currently is for Map data.

In-Vehicle Displays

The hottest map application as it pertains to traveler service information is currently in a pilot type mode in Orlando Florida and Los Angeles California among others. One such In-Vehicle terminal utilizes on-board sensors and/or GPS and map matching techniques to determine it's location. Each car carries it's own set of maps loaded on a CD ROM. The display remains fixed and the map moves as the car does. The user has a choice of several scales of maps for viewing his /her location. The driver typically enters his/her location and the map will show you were it is. In this case the route is not defined, so the user must make the final routing decisions. (Some other technologies offer a routing capability for a slightly higher price). Information from the TMC is broadcasted to the vehicle where traffic and incident information is plotted on the map. The information is color coded to congestion levels etc. This information is broadcasted every five minutes. As mentioned above, the link to the control center here is very important. As locational information is passed from the sensors, radio, video etc. within the TMC, the traveler information center must retrieve the same information. In order for this to work, the mapping data must stay

consistent and accurate. Incompatible mapping scales will ultimately mean different things to different people.

Even more recently the vendors of these devices have added yellow page information, along with advertising and tourist information linked to the maps. This expands the number of applications that these devices can be used for.

Internet and Kiosks

Recently the same ATIS information being provided by the TMC has been made available through the World Wide Web (Internet). These sites offer the traveler information before he/she moves to their car. Mapping information is color coded to the congestion level. The map is ultimately a mirror of the map in the control center. In some places roadway video is available as a part of the internet location. Users can visually see a snapshot of current road conditions updated every 4 - 8 minutes. Additionally, tourist information can be displayed within a geographic radius along with routing information to get to the attraction. Similar information is also available at public kiosks located in the local mall or store. The future of this type of application is very big, due not only to its low cost, but also to the availability of real-time information from the Internet.

Route Guidance

See ATIS Examples above.

Incident Management

The incident management application within this bundle applies to the detection and management of Non-recurrent congestion. Since a significant portion of Traffic congestion is caused by accidents or other incidents, this is a key function for ATMS. Specific elements involve surveillance, monitoring, control and decision support.

The GIS-T component as in most applications can assist with the decision support. Once an incident is detected via a road sensor or video monitor, a record is logged. Once completed, a strategy must be created. This strategy may involve response from other organizations like police , depending on the incident. The record of the incident may then be simultaneously shown on their map oriented dispatch system (See section 3.3.4), were coordination and removal effort duplication can be fostered. Another option would be a route diversion for vehicles communication to the driver through either changeable message signs or In-vehicle terminals.

As a preventative measure for Incident management, Repair or Tow vehicles can be prepositioned to minimize response times to an incident. This type of a scenario is similar to the System Status Management SSM application for Emergency Medical Response described in section 3.3.4, and very dependent on GIS-T data a source for it's use.

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4.4.2 Public Transportation Industry

Public transportation management En-route transit information Personalized public transit Public Safety Security

As with most of the individual technologies, the public transportation industry also sees GIS-T technologies bringing together information from various sources via a common map database. It was recognized that the digital road network would be essential in systems providing customer information, analyzing system performance, and monitoring public assets. Eventually, the system would be able to communicate through a map, coordinating many transportation modes.

Some of the application areas requiring a Map Database can be further subdivided into the following:

1. ***Demand-responsive Systems***
   (Paratransit, Dial a Ride, Ride-matching, Car van pools)
   Computer Aided Dispatching and Fleet Control
   Automatic Vehicle Location
   Demand Response Dispatching

2. ***Fixed Route Operations***
   Computer Aided Service Restoration / Route Deviation
   Improved Transfer Points and Connections / Timed Transfers
   On-Time Performance Monitoring

3. ***Analysis and Planning***
   Service Planning
   Market Analysis
   Ridership forecasting

4. **Customer Information** (Multimodal)
   Kiosk
   Itinerary Planning (Telephone or Internet Based)
   real-time updates
   Park and Ride
   Car and van Pool Ride-Sharing

5. **Safety and Security**
   Police Operations
   Accident / Incident Reporting
   Emergency Dispatch (Subway Operations)

6. **Maintenance**

7. **Transit administration**
   Reporting

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4.4.3 Advanced Vehicle Safety Systems

longitudinal collision avoidance
Lateral collision avoidance
Vision enhancement for crash avoidance
Safety readiness
Precrash restraint deployment
Automated vehicle operation

Although Advanced Vehicle Safety systems may feed the decision support functions within the vehicle, there are no real mapping or GIS-T requirements for this bundle.

4.4.4 Emergency Management

Emergency notification and personal security
Emergency vehicle management

Computer Aided Dispatch Systems (CAD)

Map related Requirements

- Provide a medium through which the dispatchers and call evaluator position with a work screen and vehicle status display. Color must be used to provide information where possible.
- The system must be able to support the ANI/ALI data from the most recent E911 call received on each line, so that address information can be retrieved to establish the callers location.
- The dispatch system should be capable of generating an incident report that assembles and sequences all the time and location points of all units associated with a given incident.
- The dispatch system must verify the address of the emergency, as entered by the dispatcher/call evaluator or as received from the E911 or alarm monitoring system , with sufficient accuracy to place the incident accurately on a map display and to recommend the most appropriate vehicle based on Proximity, availability and status of the vehicle. The search time for the address verification must be less than 1 second elapsed time 95% of the time.

Potential files used for address verification are:

- Municipal Address (Building location address)
- 100 Block (Block addressing)
- Intersection
- Alias file (Alias for common place names)
- Common place names

For any address search , if more than one match is found, the dispatch system should be capable of displaying a list of all possible matches and allow the dispatcher/call evaluator to choose the correct one.

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- The system should have the ability to locate a patient location address on map by zooming into an area, and selecting either an address, intersection, road segment or description of a location.

- The dispatch should be able to display any known emergency vehicles and display their status (Color).

- The system must be able to use the map for customized development of deployment plans, and must automatically change deployment plans at user specified times; and must recommend coverage moves. This activity is common for Ambulance Computer Aided Dispatch systems, where the vehicles are placed based on incident statistics (i.e. number of accidents in a certain area). This gives the vehicle the chance to respond quicker given a shorter distance to a possible incident. This activity is often called System Status Management (SSM). Criteria used for this activity is: Average number of request for service per hour, average high number of request for service, maximum requests for service, average length of time to complete a call. Can monitor the status of the unit to build intelligence.

- The CAD system must be capable of interfacing with the Automated Vehicle Location (AVL) controller and to collect and process the reported location of all units equipped with AVL.

- The CAD system must be able to recommend the most appropriate units for assignment to a given incident based on:

  Shortest distance to be traveled from unit location to incident location using existing roadways, and user definable rules i.e. all reports of plane crashes requires an specialized unit and a supervisory unit response.

  Via a map the CAD system should have the ability to dynamically redefine dispatch areas, and have the results reflected in the dispatching decisions.

  The CAD system must have the ability to locate historical incidents of the same nature at the same address or within the immediate vicinity.

  The CAD system must be able to calculate the kilometers traveled based on the X and Y coordinates for unit, patient and destination.

  The CAD system should be capable of recording, graphically displaying and using the best route calculation, all temporary road closures and their levels

  Display a trip report of incidents on a map of the city. Produce presentation quality maps with historical incident data.

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4.4.5 *Commercial Vehicle Operations*

Commercial vehicle electronic clearance
Automated roadside safety inspection
On-Board safety monitoring
Commercial vehicle administrative processes
Hazardous material incident response
Commercial fleet management

GIS-T technology plays a large role in the management of commercial vehicles. In addition to the routing and dispatching of vehicles via a map base, the following applications utilize GIS-T technology:

- Automated roadside safety inspection
- Commercial vehicle administrative processes
- Commercial fleet management

Automated roadside safety inspection

Since the safety inspectors job also includes the enforcement of Overheight and Overweight vehicle permits, the application of mapping technology will ensure that this task can be done accurately given appropriate restrictions. Mapping technology will be used to generate a route map for all those vehicles applying for such permits. The process is done completely electronically combining known criteria for overhead height and vehicle weight restrictions with routing software to calculate the best path. The final result is a permit that can be faxed optionally to the vehicle with a map, showing the exact path that must be taken. When safety inspectors ask for the permit, during a random inspection, it will pretty easy to tell if the vehicle has deviated from the defined route or not.

Commercial vehicle administrative processes

GIS-T data can help the administrative process, through the ability to automatically log miles and times for specified vehicles. Mileage can be calculated along the defined route, as a the vehicle picks up a coordinate location via it's GPS receiver. This process will eliminate the need for mileage logs and time records. These will be created automatically.

Commercial fleet management

This definitely is the most popular function within this bundle. Commercial fleet operators are realizing the enormous potential of using Map based technologies for this application. Some vendors have combined their software with GPS receivers in the vehicle to be able to locate, route and dispatch a unit given certain up-to the minute criteria. The system will also log miles, hours and incidents as a part of the administration functions.

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4.4.6 *Transportation Demand Management*

Pre-trip Travel information Ride-Matching and reservation Travel demand management

All the functions contained within the Travel demand bundle can also be related to mapping functions as well. Utilizing either on line traffic information, or static map data with address matching, there has been a series of products on the market that can compute travel or tourist information. This trip information can be calculated at home via the internet sites, via a portable hand held unit or in-vehicle via the map matching capability of companies like Etak. In both cases, real-time travel information is supplied by the TMC.

Pre-trip Travel information

The pre-trip travel application is probably the most sought after transportation information available. In congested areas travelers want to query the status of the roadways prior to departure, or plan a trip based on several destinations. As mentioned earlier the map based congestion reporting is currently being offered by private organizations via the internet, through a subscription service. This system usually ties into the local ATIS system and is combined with online traffic reports. The only problem here is that the users do not want to pay a lot for this service.

For tourist type planning, there is a great deal of information available via the internet by local trade organizations. The challenge here is to offer a similar service to the traffic reports, by tying in all the tourist spots via a map. Another application of the tourist type application was demonstrated via the TravelGuide project in Toronto, were the information was loaded on a , portable device, for query as needed. See Section 5.1.1 under Navtech for more information.

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5. Assessment of Canadian Capabilities for GIS-T

5.1 Overview

The information included in this section will discuss the current status of the Canadian marketplace for GIS-T technologies related to ITS Applications. As the market can be a very diverse one, it is always difficult to cover all activities that may be related to GIS-T. The following will assess the Canadian Capabilities based on the ability to supply "value add" to the applications and industry needs defined in the previous sections.

5.2 Data

As mentioned within the industry needs section, data is the centerpiece of all GIS-T applications. Without the data, their would be no demand for the technology that utilize it. Thus , data can be defined as the primary component for Canadian success in delivering GIS-T technologies to the ITS marketplace.

There are two primary sources of GIS-T data for ITS Applications: Commercial and Government. Within these areas there is a variety of data, that can provide an excellent base for map related ITS applications. This information can usually be delivered in the following ways:

- A graphic representation of a street or road network. Includes street names, but is basically unintelligent data.
- A graphic representation of a street or road network via a single line network file. This information also contains intelligence for street addressing through linkages at each road intersection.
- A geographic representation of a street or road network via a single line network. Additional intelligence has been added for Street addressing and points of interest.
- A geographic representation of a street or road network via a single line network. Additional intelligence has been added for Street addressing and points of interest. Further intelligence is added through the linkage of information as Direction of traffic, Heights of underpasses. Turn restrictions, distance from interchange etc. This type of information is essential for proper navigation routines.
- Database information that can be associated with the geographic representation of a roadway, through a coordinate linkage, address location or graphic link. Some examples of this data are either Yellow Page Information or Census data.

Although there is a variety of different data sources available throughout both commercial resellers and government agencies, only the originators of the data appropriate for ITS applications, and those resellers who add value to that data will be discussed. This section will outline the current status of GIS-T data suppliers and the products they offer.

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Data Standards and Policies

Although a complete Canada-wide survey was not undertaken, it is clear from the contacts made during this study that there exist many standards related to transportation data required for ITS applications. Some of the data required, specifically geospatial data, suffers from a combination of too many disjointed standards in some cases and total absence of standards in other cases. The connection to ISO is limited and it is uncertain as to whether any linkage has been made at the international level to have the Transportation (TC 204) and the Geomatics (TC 211) Technical Committees sharing developments and agreeing on common needs, semantics, data structures and data standards.

There is a parallel need for data related policies to be reviewed relative to the sector development initiative. Policies currently in place should be reviewed relative to their appropriateness for nurturing the ITS sector. This process would also provide the experience in matching policy to industry needs which would become an exportable consulting commodity in the global marketplace.

5.2.1 Commercial Data

Commercial data can be defined as that data which is sold through private organizations. These organizations usually strike a relationship with a number of the originators of such data (Either a Government or large Commercial organization) and amalgamating the different sources into a comprehensive data set targeted at a specific application. Many times the data supplier will also enhance the datasets themselves through information gathered from other sources, verbal, written or otherwise. Given this method of operation, the main objective for Canadian data resellers is the ability to supply GIS-T data to the people that want it, at a price that they can afford. Some other factors effecting the potential success of business venture within Canada are as follows:

- GIS-T information may have to be supplied from several different sources. Much of the information Off-the-Shelf may not be suitable for ITS applications, requiring the amalgamation of multiple data sources.

- Crown Copyright Laws prevent the resale of information originating from a government source without royalties being paid back to the originator. This gets pretty sticky when there is multiple copies of the data required for a final solution.

- The size of the marketplace - In Canada, the population of the country contributes to a smaller product demand.

- The need for government to generate revenues from resources - Since governments are short of cash, there is a renewed emphasis on revenue generation. This has translated into the sales of information. GIS-T data is no exception.

The result of having to compete in this environment has yielded only a few resellers of this data. Many have reverted to creating their own data, and combining it with other marketing related information to sustain a lucrative business. The standard for these organizations is to sell geographic data, database information, software to view it, and services to integrate and use it.

Based on the new model, this marketplace has become a very specialized game. The following list of vendors are the leaders within the Canadian marketplace and have either been the originator of GIS-T data or have added value to a product from another source.

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Bell Canada - Infodirect

To this point in time, the primary market for this data has been commercial marketing, Market research, Telemarketing etc. Within the ITS context, Yellow page information has been identified as key information resource in creating applications for Tourism, Navigation and Traffic information. The yellow page information can commonly be used to guide a user to a local business, restaurant, or other service oriented location. Unlike the United States where the electronic Yellow page information is resold by a variety of different dealers, Bell Canada provides electronic yellow pages information in Canada through Infodirect (a division of Teledirect Publications. The people who publish the Yellow pages). Teledirect rents the information to anyone via any medium possible. As the information is rented, the user pays by the month. This rental ensures that all the users get the most recent and up-to date data. Some of this information is also available via the Internet. One example of this is through Edmonton telephones at http://www.edmonton.com.

This information can be essential for building links to the single line network for routing type applications are required to specific points of Interest. Those are included in the Yellow Pages. The common link is via the address.

Canada Post Corporation (CPC)

Canada Post is the nation's supplier of postal services. As a part of this mandate Canada Post has created a system that will assist with the routing of postal carriers and delivery vehicles. The technology that is used to do this is called GeoPost. GeoPost uses an up-to-date digital representation of all streets for more than 270 cities and towns with associated postal codes, street names and address ranges to accomplish it's sophisticated routing procedures.

The data that is used, incorporates information from Statistics Canada SNF files, Natural Resource Canada's, National Topographic database (NTDB), and various provincial and municipal governments data. The database is updated daily through requests for address changes and new subdivision applications for postal services. The result is in fact one of the most complete and up-to-date geographic address databases in Canada.

Canada Post offers many services through which the database can be used including specialized mailers and market research. The one service that it cannot offer is the sale of the information. This is due to Canadian Copyright laws, and the fact that CPC used Statistics Canada's information as a basis for it now owns. There is no current agreement between Statscan and CPC for the rights to resell or provide royalties. An action on this is pending.

Compusearch Micro-Marketing Data and Systems

Compusearch is the leading supplier of geographical data and marketing databases in Canada. For over 19 years Compusearch has been building databases specifically for the Canadian marketplace. They are linked to the US firm, Geographic Data Technologies (GDT), through one of their parent companies POLK data marketing (See Section 5 for more info on GDT). As with most of the companies listed in this section, Compusearch has several dealers worldwide. One of those dealers is ETAK Menlo park, California. (See Section 5 for more info).

They offer a variety of different information related to geographic street and highway information in any format. Some of their primary products include:

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Enhanced SNF - Compusearch supplies Statscan's Area Master Files (AMF) and Street network Files (SNF) which contain information for streets, roads, highways, shorelines, rivers, highways ramps, bridges, railways, canals, parks and other selected features. This information has been enhanced to include missing address ranges and street segments. The transportation routes are center-line street files which include names and address ranges for each segment. See section on Statistics Canada for more information on AMF or SNF files.

Streetscapes - The same as above excluding street labels and address ranges.

Streetlites - Again, these files are the same general product included in AMF/SNF files, however the street files have names included but not address ranges. This product has been enhanced to through cleaning up the vector information where required, and have been made consistent and topologically sound. Compusearch's highway files have been included and adjusted to fit the urban streets were necessary. Additional major roads and streets have been added in specific urban data sets to enhance the coverage.

Street Classification File - This database classifies the street segments into four different categories : Freeways, arterials, collectors, and local streets. This file can be used with any of the other products mentioned.

Highways - A file containing all the digital vectors and names for all Canada's major highways. This file is available as a stand-alone product or integrated into any of the urban street files. This file also includes place name information (i.e. Town names etc.)

Compusearch also offers a series of 1991 census files for things like population density, and enumeration areas. Full census records are not available due its sensitive nature. They do however offer full databases for other locational information. This information has been geocoded and can be located via any of the other map products they supply. These include comprehensive databases for Businesses, Shopping centers, Restaurants, Financial Institutions, Grocery stores, Drug Stores, Physicians, Dentists, Hospitals and Nursing Homes. When linked to a street network file, this information could be included into an Advanced Traveler Technology.

Compusearch is also a distributor of Smart Maps raster maps on CDROM. This data provides an excellent backdrop for all map related ITS applications. Both Street maps and provincial topographic mapping information is available.

The following table outlines Compusearch's coverage of Canada for single line street files.

Table 2.0

CITY	SNF FILES	CENSUS TRACT	STREETLITES
St. Johns NF	•	•	•
Halifax NS	•	•	•
Moncton NB	•	•	•
Saint John NB	•	•	•
Fredericton NB	•		•
Chicoutimi PQ	•	•	•
Quebec PQ	•	•	•
Sherbrooke PQ	•	•	•
Trois-Rivieres PQ	•	•	•
Montreal PQ	•	•	•
Saint-Jerome PQ	•		•

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Ottawa-Hull ON	•	•	•
Kingston ON	•	•	•
Belleville ON	•		•
Peterborough ON	•	•	•
Oshawa ON	•	•	•
Toronto ON	•	•	•
Hamilton ON	•	•	•
St. Catherines ON	•	•	•
Kitchener ON	•	•	•
Brantford ON	•	•	•
Woodstock ON	•		•
Guelph ON	•	•	•
Stratford ON	•		•
London ON	•	•	•
Windsor ON	•	•	•
Sarnia ON	•	•	•
North Bay ON	•	•	•
Sudbury ON	•	•	•
Sault St. Marie ON	•	•	•
Thunder Bay ON	•	•	•
Winnipeg MB	•	•	•
Regina SK	•	•	•
Lethbridge AB	•	•	
Calgary AB	•	•	
Red Deer AB	•	•	
Edmonton AB	•	•	
Kelowna BC	•	•	•
Kamloops BC	•	•	•
Matsqui BC	•	•	•
Vancouver BC	•	•	•
Prince George BC	•	•	•
Victoria BC	•	•	•

Navigation Technologies Canada Inc.

Navigation Technologies Canada is a subsidiary of the larger US parent Navigation Technologies (NavTech) / European Geographic Technologies BV (EGT). (See Section 5 for more detailed information).

Navigation Technologies Canada plans on creating a truly navigable database for all primary cities in Canada. The current target is for those cities with 500,000 people or more. Once completed Navtech will move to the secondary cities and so on. They are currently hiring staff in their head office in Toronto, and hope to be in full operation by mid year.

Being very successful in the GIS-T for ITS applications area applications around the world, they should be able to take full advantage in creating a successful operation here as well.

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Teranet Land Information Services, Inc.

Teranet is a private corporation jointly owned by the Province of Ontario and a private sector consortium including Altamira Securities, EDS Canada, SHL Systemhouse, Intergraph, and KPMG. Teranet's mandate is to automate the provincial land title registry system. Also part of this mandate is to provide associated information back to it's customers. Teranet has agreements with a number of Ontario municipalities, utilities and other organizations to supply digital mapping and associated information maintenance services.

Although Teranet's primary goal is within the land titles area, the final product that will be created from this activity will be a very accurate representation of the land parcel fabric including right-of-ways. Within the next year Teranet plans to generate a single line street network from this land fabric. The result will be a very accurate navigable network. As with Canada Post, the requirement to maintain this parcel fabric is a core piece of their business, and the information will be updated dynamically.

Teranet currently does not sell a single line road network. Plans for the sale of the network is unknown at this time.

Other Commercial Data Vendors

Although the aforementioned firms are the leading vendors of data for street line based applications in Canada, there are many small companies that also supply this information. Often these firms can be contacted either through the crown properties department in any provincial ministry, or by contacting one of the other government departments mentioned in the next section. Often these vendors just sell paper or digital map information without any intelligence.

5.3.2 Government Data

Currently the primary source for generating geographic based data for use within ITS applications is a government agency. Across the country, the Provincial MOT's and the more progressive municipalities, have experimented with the use of GIS-T data in one capacity or another. Many have used this information as a better way to store and display their road inventory, while others are using it to map accident trends and create expenditure planning scenarios for pavement management etc. Federal agencies use the data for their particular niche interests like the production of voter lists. Either way, mapping information has become the core of many systems within government. Much of the information that has been generated by these organizations can also be used within ITS mapping applications.

British Columbia

The BC Ministry of Transportation has established a Provincial Transportation Centerline Network - TCN to the Scale of 1:100,000. Agreements have been made with local municipalities to include their street networks as a part of this provincial data set. It can currently be purchased through the crown publications or through a dealer.

A pilot is underway utilizing a portion of this network in a dynamically segmented form to assist with infrastructure management activities. BC is moving towards a mapping interface for their Advanced Traffic Management system within the Vancouver area.

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Alberta

The Province of Alberta Transportation and Utilities (ATU) maintains a dynamically segmented single road network for the provinces primary, secondary and township roads. This data currently resides in Intergraph MGE format and is available via ATU's planning department.

All three of the Provinces largest cities maintain their own single line networks. The Cities of Calgary, Edmonton and Lethbridge currently include address ranges and point of interest as a part of their databases. Only Edmonton includes information such as direction, height restrictions, turning lane information etc. as a part of their database. Calgary plans on having this information in place by year end.

The reason these three cities maintain this information is because of the need for their map based Computer aided dispatch systems. Lethbridge is currently dispatching Police vehicles, Edmonton has Fire, Ambulance and Police, and Calgary will have Fire on-line before year end. Edmonton also has a tie to their Traffic management center. The status of that project is currently unknown.

Saskatchewan

Saskatchewan will be maintaining a single line street network file through their Central Surveys and Mapping Agency (CSMA). Based on a provincial government mandate to coordinate geographically based information through CSMA, the single line network information will be passed from all major contributors such as the Provincial MOT and the cities of Regina, Moose Jaw, and Saskatoon, back to the agency. CSMA prides itself on open data exchange formats.

Manitoba

The Manitoba Department of Highways maintains a Single Line Road network for the provinces primary and secondary roads. The data was originally created from the provinces Topographic database, maintained by Linnet Geomatics. The highways network is segmented through control sections. The single line network for the City of Winnipeg is also currently available, status unknown. Aerial photos have also been introduced in remote areas to fill in coverage were no other vector data is available. This information is also available through Linnet Graphics.

There is no known ITS projects within Manitoba that are utilizing GIS-T data at this time.

Ontario

The Ministry of Transportation of Ontario - MTO currently maintains a single line road network for all Primary, secondary, township and selective municipal roads. This information is based on 1:100,000 mapping with an approximate accuracy of +or - 100 Meters. There are currently two contracts underway defining this network for Southern and Northern Ontario, which will be completed by year end. The Southern Ontario data will cover all township boundaries, primary and secondary roads with street labels. The Northern Ontario data will be the same as the Southern Ontario data, only all cities and town roads will also be included. The primary and secondary roads for all datasets, are dynamically segmented for the purposes used solely by the Ministry. The Ministry of Transportation sells all their data through the Ministry of Natural Resources, who is unofficial keeper of the province's geographic data.

The Ministry of Natural Resources - MNR uses the Single line network generated by the MTO and combines it with their other geographic data products to sell to the public. Most municipalities have used the MNR Ontario Base Mapping information - OBM (Scale 1:10,000) to establish their own street line network.

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Many of the municipalities in Ontario have taken various forms of Street Line information from sources like Statistics Canada - SNF, Cadastral data from the Ministry of Finance, MNR OBM mapping and local survey databases. The result is an accurate Single Line file covering all municipal streets and addresses. The local municipalities are also maintaining these networks as a part of their standard GIS services. Some known municipalities that currently maintain their own single line network are the following:

City of Toronto
Regional Municipality of Hamilton-Wentworth
Regional Municipality of Metropolitan Toronto
City of Oshawa
Regional Municipality of Ottawa-Carleton
Region of York
Region of Halton
City of London

Recently, the Ministry of Health - MOH has expressed interest in obtaining these Single Line networks to include them as part of their standard Single Line Road Network - SLRN master map base. The objective of the SLRN is to address the mapping needs of the potential provincial wide computer aided dispatch project. Although this project is of a high priority, the population of the Ontario SLR Network has been currently delayed in it's development, due to provincial funding cuts. To date, the section of eastern and southwestern Ontario have been completed as a part of pilot project which began in 1994. As a way to continue this project, the MOH is negotiating agreements with various municipalities to provide them with their own SLRN. Details of this arrangement are unknown at this time.

Ontario is one of the leaders in use of GIS-T data for ITS uses. There are currently projects at The Region of Hamilton-Wentworth and Metropolitan Toronto to use mapping data as a basis for computer aided emergency services dispatch. Toronto and Ottawa are using a GIS base map to identify transit scheduling for regular and paratransit services.

The Ministry of Transportation has completed a pilot project for it's TravelGuide system, which uses mapping information on a portable unit to locate points of Interest or tourism attractions. For more information see the brief on Navtech in section 5.

The Ministry have also implemented a map in their main control room for the Advanced Traffic Management system. The Advanced Traveler information service including links to the map, will be available later this year. MTO is also involved in the creation of the ITIS protocol for use of this data within routing applications. A standard that will facilitate the interface to existing MTO ITS technologies. For further information contact MTO at the address listed in Appendix F.

Quebec

Quebec is currently investigating the use of mapping technology as a part of their Advanced Traffic Management System. Although they have made important strides within the overall ITS arena, there has been no known progress within the GIS-T area by the author at this time.

New Brunswick

The Province of New Brunswick maintains a provincial road network through the New Brunswick Geographic Information Center - NBGIC and the Ministry of Highways. The current Single Line Network covers the provinces primary and secondary highways at a scale of 1:10,000, and includes street maps for all major centers. The highway information has a linear referencing

system defined and is available to do dynamic segmentation type queries. There is also metadata and transfer standards defined by NBGIC that also govern this information.

Nova Scotia

Nova Scotia is currently assembling their single line road network for the provinces Township boundary, primary and secondary roads. The information is based on information provided by the province's Center for Geographic Information - NSGC, and that provided by the federal government at a scale of 1:50,000 and 1:250,000. Municipal street information is available for Halifax, Dartmouth and Halifax County via the City of Halifax.

There are currently no known initiatives in Nova Scotia that utilize geographic information for ITS applications.

Prince Edward Island and Newfoundland

Both the province of Newfoundland and Prince Edward Island currently maintain their single line highway network via their corresponding Geographic Information Centers.

There are currently no known initiatives in Newfoundland and Prince Edward Island that utilize geographic information for ITS applications.

Federal Government

Inter-Agency Committee on Geomatics (IACG)

The IACG was formed several years ago to address the needs and concerns of the individual federal ministries. Throughout the life of this committee there has been several issues raised like data compatibility, common datum's, standards, effort duplication and coverage. Although some of the minor issues have been addressed, many major ones are still outstanding. Geomatics Canada still chairs this committee, and has pledged to continue to try and resolve any issues.

Statistics Canada

Support of the Single Line Network File (SNF) has been the main focus of Statistics Canada's Geography Division for several years now. In support of the field operations for the 1991 Census of population, the Geography Division relied heavily on GIS for the creation and dissemination of data. Using the SNF databases, combined with administrative boundary files and other statistical information, GIS activity allowed Statscan to produce better enumeration collection maps, with the ability to produce other associated map series. The GIS would also provide an excellent environment for information maintenance, reducing the amount of input required prior to each census.

Statscan's SNF database covers only Canada's large urban centers, which comprises less than 1% of the total Canadian land mass, but approximately 60% of the population. Based on the success of using GIS for the 1991 census, the geography division investigated the possibility of increasing their coverage into the rural areas. This investigation involved discussion with Elections Canada, Canada Post Corporation and Natural Resources Canada in order to obtain the information missing from their current datasets. After establishing a prototype project called "Route Canada" the result ended with several data incompatibilities between agencies. Specifically, the Map Features, Naming conventions and Datum used were incompatible. Although there is no working relationship between Statscan and NRCan, there is currently a very

strong working relationship with Elections Canada. The result means a stronger product containing accurate street addresses, based on current census's.

Currently, Statscan offers a 1:100,000 map series which includes street addressing based on each federal census. The database has been known for it's inaccuracies, but still remains the only product of it's type available.

Statscan supplies their data products to the public either directly or through dealers. They supply their data directly via Arc Export format (a proprietary data format from Environmental Systems Research Institute (ESRI)) formats are available upon request.

Geomatics Canada

Geomatics Canada is Canada's national surveying, mapping and remote sensing organization. It is the focal point in the federal government for the creation, management, distribution and use of geographically referenced information. Geomatics Canada is very active in the promotion of geographic standards, maintenance of existing geographic databases, and research and development in partnership with industry.

Geomatics Canada offers two scales of topographic information, 1:50,000 and 1:250,000. These scales are the standard for the entire National Topographic Database - NTDB, which is the basis for all their data products. One such product is the Canadian Road Network.

In an effort to best address the growing need for Map data within ITS applications, Geomatics Canada is addressing three key issues as a part of their future product development:

1. Address matching - Adding address information to it's current Digital Road Networks
2. Map Matching - Ability to match a road network with an associated GPS location.
3. Best Route Calculation and Route Guidance - application software based on address matching and map matching capabilities.

Geomatics Canada is currently reviewing the way that they are pricing their data, and are also looking into partnering with Canada Post and Statistics Canada to integrate their data sets. The status of these issues is unknown at this time.

Transport Canada

Transport Canada uses mapping for the many of their core functions. Digital mapping information is used for identifying facilities at Airports, Ports and Harbors, and establishing transportation economics policies and programs. As a part of this mandate, a viewing tool for geographic information has been adopted. Mapinfo is the tool that has been selected, which along with visual basic has been incorporated into the current information access environment called T-Facts. Throughout the various departments of Transport Canada there has been enhancement of various forms of Geographic data, they are:

- The analysis of the rail network in Canada yielded a 1:2,000,000 scale map of Canada's railroads.
- The analysis of the road network in Canada using a gravity model generated a single line street network with Highway number, From, To, number of lanes, Speed limit, AADT, Truck Share and additional information was added to complete the National Highway System.
- A system was created to allow users access to maps detailing Transport Canada's Highway investments.

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- Transport Canada has completed a National Highway Map to be integrated with US and Mexico data to produce a NAFTA transportation route map. The scale will at 1:1,000,000 and is scheduled to be available free of charge in early 1996.

Through several meetings Transport Canada has attempted to establish a working group on transportation related Geographic Information. As they do not generate information of their own, the objective is to foster data sharing irrespective of Copyright. The mandate is currently to work among government agencies. Status of this committee is currently not known past the initial meeting.

Elections Canada

Elections Canada currently use Statscan's SN Files as the basis for the creation of voters list during every federal election. Geomatics Canada's NTDB files are also used for the areas not covered on the SN Files. Specifically, they use geographic data to help assist canvassers in the location of specific addresses, establishing polling districts, and generating voter lists. Canvassers also update the information through manual methods on-site, which is then updated to the national database later at headquarters. Since canvassers log every change to the database, the resulting address information is probably the best kept in Canada.

Currently, the information updated by Elections Canada is in fact the mechanism used to maintain the Statistics Canada Street Network file.

Defense Canada (DND)

The Department of National Defense is probably one of the largest users of digital mapping information in Canada. As a part of their legislated mandate to protect the borders of Canada and her people, DND has produced a series of digital maps ranging from 1:10,000 to 1:250,000. Specifically the 1:250,000 scale map series cover the transportation modes across Canada. Although this information would be an excellent asset to the ITS industry, it is not for resale due to it sensitive nature.

As a result of having to work closely with all the NATO Allies throughout the world, DND has been involved over a number of years with the development of Geographic Data Standards. As a result the current accepted data transfer standard for intelligent geographic data is DIGEST.

Summary

Provinces of smaller size tend to have a better coordination of their Geographic data. This is partly due to their ability to get consensus by more than one jurisdiction easily. Often the data that is created by these provinces tends to be updated more frequently, creating a far better mapbase as well. The down side of this scenario is the fact that the majority of demand for ITS developments are primarily centered around areas with a large population.

Overall, there are many Single line network databases across the country. All of them employ different data structures and scales, Varying accuracy, and overlapping coverage. There is currently no coordination between federal level data suppliers and their provincial and municipal counterparts that would assist in the creation of one comprehensive data set for a given area. Additionally, crown copyright legislation and desire to recoup data creation / maintenance costs has hindered this from happening.

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5.4 Research & Development - GIS-T Related Technologies

There are several ITS related research programs currently underway within the Universities in Canada. Although most of them have generated encouraging results , only the programs at three universities have been related to GIS-T or mapping within ITS. They are:

Ecole Polytechnique Montreal

This technical university has been know to concentrate on the development of intelligent software for transportation applications. Their transportation program has been identified as one of the best for Information technology research within the transportation sector. Current projects underway at the university were unknown at the time of publication, but they are working extensively on routing applications.

Universite de Montreal

The Universite of Montreal is the second university to come out of Quebec with a focus on the development of intelligent algorithms for Network Analysis. Some of these developments that can be used with GIS technology are:

- Temporal Traffic Assignment - analytical Boundaries
- Dynamic Routing Methods for ITS
- Parallel Software Applications for ITS
- Temporal Transit Assignment
- Micro Simulation of Vehicular Traffic for ITS

University of Calgary

The University of Calgary has produced some excellent GIS-T related research as it pertains to Navigation technologies. There has been a great amount of research into the adaptation of navigation information to a mapping interface. As a result the University has developed line following techniques to match GPS locations to single line street files.

The fact there is not a large number of universities on this list, does preclude that other colleges and universities are not doing GIS and/or ITS research. Based on the scope of the search and industry knowledge, only these have been identified with significant accomplishments in GIS-T related applications for ITS. There are other developments currently underway at both the University of Queens and the University of New Brunswick in ITS, but is unknown if they have a GIS-T component.

5.5 Systems Integration and Software Development

Based on what has been discussed in the previous sections, the demand for software and data is very high in order to build GIS based ITS applications. Although data was identified as the key to GIS based application success, software development with intelligent algorithms can be defined as the core of the application to be resold. Without them intelligent decisions associated with ITS deployment would not exist. As most of Canada's ITS systems integrators for GIS-T applications, also develop their own software, they will also be included in this section. Those Integrators who focus primarily on consulting, will not be listed in this section. See Appendix F for all known consultants..

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AVL Automatic Vehicle Location Systems Ltd.

AVL has a background in the implementation of GPS and other navigation systems, mobile data telemetry, geographic information systems, and application software development. Their specialty is the implementation of small scale commercial fleet management systems.

International Road Dynamics Inc (IRD)

IRD offers a wide range of talent for the full scale implementation of various ITS applications. They have extensive experience in the integration of GPS and mapping data as a part of their overall offering. They currently market and sell a product for GPS and Automatic vehicle Identification with real time dispatch, called TransView.

M3I Systems Inc.

M3I provides custom, computer based, modular solutions for ITS applications using GIS-T technologies like:

- Computer Aided Dispatch (CAD)
- Automatic Vehicle Location (AVL)
- Intelligent mapping systems (GeoBase): electronic maps created through an application of differential GPS technology.
- Tourism Applications (GeoAccess)
- Ruggedized mobile computers (PCMobile)
- Control Room Display Systems (MOSAIC)

M3I also runs RoadSoft Solutions, who serves the public Safety and Fleet Management marketplace to provide solutions for Dispatch management and Vehicle Tracking systems.

Pulsearch Navigation Systems

Pulsearch specializes in the manufacturing of end user surveying and navigation products and the design, fabrication of special use hardware for the Geomatics industry. Started out of the department of engineering at the University of Calgary, this company currently markets the NavTrax AVL navigation dispatching system, with positioning, communication, digital mapping and dispatch center components.

Morrison Hershfield Limited

Morrison Hershfield is a consulting engineering firm with expertise within the transportation and telecommunications industries. They specialize in the development of Traveler information systems , Decision support systems and expert systems. MH has produced software to simulate transportation models for the evaluation of multi-modal applications in Southern Ontario. They have also produced route planning and scheduling model for optimizing the delivery systems at the Edmonton Journal.

GIRO Enterprises Inc.

GIRO produces a multi-purpose tool that includes capabilities for address geocoding, map production, vehicle routing and the calculation of distances and travel times. It has been primarily designed to optimize routes for government or commercial fleet operations.

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Georoute has been designed to solve both link (or Arc) routing problems, when an entire street must be visited many times, and node routing problems, when an optimal route must be determined for servicing multiple points on the network level. It is currently the routing engine for all of Canada Posts delivery and postal deliver routing applications. They have also participated in several paratransit applications for pickup and delivery scheduling.

Computmap Traffic Research and Engineering

Computmap is involved in traffic research and simple routing algorithms. They have produced a route planning system that can be used standalone or in conjunction with any map data, for applications such as traveler routing and traffic flow planning.

Summary

Based on it's population and proportional amount of ITS related projects, the amount of Canadian talent that has been developed for GIS related applications is significant. Some of the positive aspects that can be attributed to Canadian talent are as follows:

- Canada is a known world leader in the general GIS arena for It's knowledge of the application technologies and data. As a result, Canada is probably the most well mapped country in the world, having data in at least all the populated areas. Along with the installation of active GPS base stations in places like BC and Alberta, navigation type applications can be easily developed.

- Out of the requirement for enhanced routing applications (Snowplow, transit etc.), Canada has developed a strong level of expertise in the Montreal area, that has been identified as one of the best in the world.

- The Ministry of Transportation in Ontario, currently has one of the best showcases in the world for the application of ITS related technology. A center through which much talent has been developed, and future applications (funding pending) will be developed. This site has had excellent press from several different fronts, around the world.

Based on the expertise that is available and the bigger market to the south for ITS applications. Canada is well positioned to deliver the technology and knowledge to ITS marketplace.

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6. Threats to Canadian Industry

In order to help create an industrial base for the development of GIS-T applications for ITS, we must identify the activities currently underway that may hinder our progress. There are five areas that have been identified as key development areas for these applications. They are Data Supply, Data Standards, Research and Development, Policies, and Assisting Organizations. This section will cover the current activities and expertise by various organizations around the world addressing this market, and how they may effect Canadian development.

6.1 Data

As defined within the needs section, data is the centerpiece of all GIS-T applications. Factors like data coverage, quality, accuracy and completeness, will make or break the development of an ITS application. The threat to the Canadian market for GIS-T technologies centers around the availability of the proper information to deploy these systems. No matter how good the technology is, without the information there will be no market. If there is a market, technology development will thrive. The following sections explain the current status of GIS-T data, within the competitive marketplaces.

6.1.1 Commercial Data Suppliers

This section discusses the foreign capabilities that have been developed for the resale and maintenance of ITS related GIS data. Having developed this expertise and being US based, there is a possible threat that they could expand to the Canadian market, limiting local growth. Although, this may seen as a negative influence, they may also act as a complementary partner with others wanting to develop assisting ITS technologies (i.e. Algorithms, Display Devices etc.).

United States

As with the Canadian commercial GIS-T data business, there are many US vendors that are resellers of large corporate and government information. Of these resellers , many have invested a fair amount of time and effort to create a product that is saleable for suitable ITS end-user applications. For most of these resellers, the data being distributed is based on the original DIME or TIGER Files from the US Census Bureau. As these files are licensed from the Census Bureau through a one-time fee, without the condition of copyright infringement, resellers have the ability to recover their investments much quicker. As a result of these policies, the US data market has been made feasible through following factors:

- Data supply businesses can recover the time and effort invested in map creation and maintenance through the resale of the data. Since there is only a one-time cost for data from the federal government. The original investment can be recovered over a shorter period of time. By adding value to the data (Enhancements, Accuracy), users will look towards the data suppliers versus the government for their information.

- Due to the wider availability and coverage of the GIS-T data, more ITS component developers can integrate GIS-T technologies as a part of their end user applications. Developers can create technologies without the fear that their product will not work in a specific geographic area. It will also foster the development of data standards, so that cooperation among all parties (Hardware, Software and Data) is encouraged.

- Revenue generated from the resale of data will foster research into new uses of the data and related technologies. US data resellers can then build the required expertise to integrate this information as a part of the ITS end-user applications. This talent is exportable.

The benefits of this environment has produced a burgeoning data businesses within the United States. There are many companies that have used the available data to create not only data for resale, but viewers and other integrated technologies. Of all these companies, two are currently dominating the market at home and abroad. Both Etak and Navtech have taken advantage of the business environment set up within the US and built a company specializing in GIS-T applications within ITS. Navtech is currently setting up in Canada, while Etak addresses this marketplace through the US, Europe and It's partners. The following is brief on both companies:

Navigation Technologies (NavTech) / European Geographic Technologies (EGT)

Since 1985, navigation technologies has been in the business of supplying comprehensive , navigable digital databases for use in advanced transportation applications. Along with it's European subsidiary EGT, Navtech is easily the industry leader in supplying Navigable digital databases. Navtech also has close relationships with the American Automobile Association AAA (Investor), Motorola Inc. US (Licensee), Nichimen Japan - (Investor), Nippondenso Co. Ltd. Japan - (Licensee), Philips Electronics Holland - (investor), Prudential R&D Funding Corp. US - (Investor), SEI technology Group US (Investor), Zexel Corp. Japan - (licensee).

They pride themselves on the accuracy of their databases, hence the ability to locate via GPS, accurately calculate desired routes and participate in real time guidance. Their databases include precise roadway geometry, block-by-block address ranges, directionality, turn restrictions, and driving rule information. Points-of-interest information is also available within their databases so that everything from cash machines to shopping malls can be located.

Navtech provides their customers with the most recent up-to-date information through a wide network of field staff within the large urban areas across the US and Europe. Over sixty of the top urban US and fifty European centers will be completed by the end of 1996.

Navtech currently has strategic partnerships with many firms, so that they can offer turn key solutions. In addition to the above relationships, some additional partnerships are:

Lightstone Group Inc. - Developers of Fleet Management Products
Rockwell Automotive - Advanced Navigation Systems
Siemens Automotive - In-Vehicle Navigation Systems
Avis Inc. - Consortium to supply In-Vehicle Security and Navigation systems.
Hertz Corporation - Consortium to supply In-Vehicle Security and Navigation systems
General Motors Oldsmobile Division - In vehicle Navigation information.

Navtech has also supplied their data to many ITS projects around the world. Some of them are:

- ***PROMETHEUS Project (Europe)*** - Supported by the European car manufacturers, this project used EGT's data as a basis for a Dual Mode Guidance System and Travel and traffic information systems. ADVANCE: Through its partnership with Motorola, NavTech is supplying the navigable database for the ADVANCE project being conducted in the Northwest suburbs of Chicago. 75 private vehicles will be equipped with navigation and dynamic route guidance systems.

- ***Transcom:*** NavTech's database is being used in a 15 agency effort to improve traffic management in 37 counties in New York and New Jersey. NavTech's navigable database will be used at the Operations Information Center in conjunction with the Transcom Geographic Information System to improve the quality and speed of inter-agency responses to traffic incidents and to coordinate construction.

- ***Fast-Trac:*** Siemens Automotive is using NavTech's database in Fast-Trac, an operational Advanced Traffic Management System (ATMS)/Advanced Traveler Information System (ATIS) field test project in Oakland County, Michigan. Fast-Trac combines in-vehicle hardware and communication beacons for dynamic route guidance and will lend insight into the costs and benefits of such systems.

- ***TravelGuide:*** The Ministry of Transportation in Ontario is spearheading this project centered on a hand-held computer ATIS application. Users in Toronto will access NavTech's database to get graphic or voice routing information that encompasses real-time traffic and transit information.

- ***TravInfo:*** Development of a publicly funded Travel Information center in the Bay Area which utilizes traffic and transit data provided by multiple authorities

NavTech also contributes its database and software to various universities throughout the U.S. for use in their ITS-related educational research and studies.

Etak Inc.

Etak Inc. is a provider of in-vehicle navigation technology, digital road maps and related application development software. Etak currently operates one of the world's largest digital mapping facilities at its Menlo Park, California headquarters.

The latest generation of Etak digital map databases - EtakMap Premium - includes USPS Zip+4 codes and Tiger '92 addresses. EtakMap digital databases cover the entire continental United States and Hawaii as well as areas in Europe and Asia. Etak's maps include virtually all roads and streets from freeways and highways through residential streets, alleys and gravel roads. EtakMap features include positionally-accurate, classified road networks and names, addresses, political and administrative boundaries, and water bodies. Other information is also included such as points of interest, landmarks, on-way street attributes, and area fill for parks and bodies of water.

Etak recently introduced a "small-scale" map of the continental U.S. road and highway network as well as a series of products containing political, postal and census boundaries for the U.S. The small-scale maps, called "EtakMap USA", are especially useful for long-distance trip planning and traveler information systems in both commercial and consumer applications. Both EtakMap USA and EtakMap Boundaries integrate seamlessly with Etak's software tools.

Etak has agreements with U.S. West and other Regional Bell Operating Companies to jointly develop digital maps incorporating business listing data for "electronic Yellow Pages" applications. Etak map data and/or software are currently being used by GM/Delco, Sony, Motorola, Clarion, Pioneer, Bosch/Blaupunkt, AirTouch Teletrac, Guidestar, Cue Network's TrafficAlert service, the Roadirector route guidance service, and many other organizations. Several consumer PC software products use Etak maps and software including News Electronic Data's "Taxi", Road Scholar's "City Streets", "Automap Streets", Software Toolworks' "Travel Companion", and PTT's "Personal Travel Guide."

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With product commitments from a variety of automotive electronics and Original Equipment Manufacturers (OEM) customers, Etak recently launched a major expansion program to accomplish large-scale production of turn-by-turn route-guidance databases in North America and Europe. Etak has joined Bosch in Germany and Tele-Atlas in the Netherlands in a consortium to produce digital road map databases for western Europe.

Etak and Sony Corp. jointly introduced an after-market in-vehicle navigation product marketed by Sony in the United States and Europe that uses map and traveler information databases published on CD ROM by Etak. Etak also publishes the PCM-CIA cards for the Delco Telepath 100 navigation radio product. In addition, Etak and the United States Geographic Survey (USGS) have a Cooperative Research and Development Agreement (CRADA) for joint development of transportation databases and digital map production technology.

EtakMap databases cover the entire continental U.S. and Hawaii plus metro areas in Europe and Asia. These databases are available in two forms. MapAccess (a highly compressed, rapid access format) and MapBase (a flat ASCII format supported by most GIS systems).
Etak Development Tools are a collection of C-language libraries including MapAccess (MapDraw, MapRetrieve and Geocode), Path access (for pathfinding and route guidance applications), and GeoRetrieve (for storage and fast retrieval of groups and classes of information in geocoded databases - example: find and display all hotels within 5 miles of the convention center).
Licenses are available for navigation software and technologies including Dead Reckoning And Map Matching (DRAMM), Heading-Up Moving-Map (HUMM) displays, and integrated Global Positioning System (GPS) navigation. Hardware designs and in-vehicle navigation development platforms are also available for prototyping, system development and demonstration programs.
Custom or standard geocoded business listing (Yellow Pages) are available from Etak. In addition, batch database geocoding services as well as custom mapping and map digitizing services are also available.

Etak has participated in many projects in both Europe and North America some of these are:

Pathfinder: Etak licensed the underlying technology for the Bosch/Blaupunkt Travelpilot in-vehicle navigation units used in this Advanced Traveler Information System (ATIS) project in the Los Angeles area. Etak also provided the EtakMap Los Angeles database and a GeoCoder workstation.

TravTek: Etak provided its MapAccess software and a digital road map database of the greater Orlando, Florida area for in-vehicle navigation, heading-up moving map displays, and destination finding from the street addresses and intersections. Etak also provided navigation software for dead reckoning, map matching and GPS integration.

ADVANCE: Etak is providing electronic business listings and retrieval software for this ATIS project in the Chicago area. Etak's navigation software may also be utilized.

TravInfo: Etak helped conceive and establish this ATIS project in the San Francisco Bay Area, including providing the Chair for its Advisory and Steering Committees. Etak, Clarion, Metro Networks, and DCI will demonstrate and test an in-vehicle navigation system complete with map displays of real-time traffic and other dynamic information. Automatic route guidance around traffic obstructions will be provided.

Minnesota Guidestar: Etak was selected as the mapping partner for this project and is also providing in-vehicle navigation technology and software to the project.

TRIMS: Sponsored by a grant from the Bay Area Air quality Management District, Etak is partnered with the City of Menlo Park, California on this Trip Reduction Information Management System which assists employees in finding public transit and ridesharing alternatives to commuting in single occupant vehicles.

SWIFT: In addition to serving as the georeferencing consultant and to assisting with overall system design of this Seattle, Washington Field Operational Test (FOT), Etak will supply (1) the Traffic Workstation used by Metro Traffic Control to enter and process real-time traffic information for broadcast by the Seiko Telecommunications high speed FM subcarrier system, (2) the geocoded business listings for destination finding with the Delco navigation radio, and (3) the software, map database and business listings to display real-time traffic and bus positions and to find destinations with the IBM sub-notebook computer.

TransCal: This FOT will serve Lake Tahoe travelers anywhere between Santa Cruz, California and Reno, Nevada. Etak will supply the map database and some of the workstation software for the TRW/ESL Traveler Information Center workstation. Etak will also supply the CD ROMs for navigation, destination finding and display of real-time information on the Sony in-vehicle navigation systems. Real-time information from a variety of sources including Shadow Broadcast Services, Caltrans and the California and Nevada highway patrols will be broadcast to the Sony/Etak systems over high-speed FM subcarrier by CUE Network.

YATI: Etak will provide map databases and software libraries for use in kiosks plus an on-line computer information service as part of this Yosemite Area Traveler Information system that will serve travelers going to and from Yosemite National Park in California. NET is the prime contractor.

Other significant US software and data supplier companies are included in the Appendix B. Geospan, Roadnet, GDT, Mapinfo.

Japan

Within Japan there is only one significant threat when it comes to the supply and creation of data. The Japanese Digital Road Map Development Organization has helped to defined digital road map standards for the entire country. The partners within this development project contained both public and private interests to create a standard through which all parties could use. Some of the automotive firms have been creating their own data on a scale of 1:2,500 for some of the larger urban centers based on the original JDRMA data.

Japan Digital Road Map Association - JDRMA

The Japan Digital Road Map Association (JDRMA) is dedicated to developing the Japanese digital road map database and associated standards for its transfer. It was established in August 1988, with 82 member organizations, to oversee the database compilation. The first database of Japan was completed in 1990 and updating occurs yearly. JDRMA produces a digital road map at a 1:25,000.

JDRMA has participated in the ARTS (Advanced Road Transportation Systems) research and development program. ARTS is developing road traffic information and digital map-based information systems. The organizations involved in ARTS include:

* Highway Industry Development Organization
* Japan Highway Public Corporation

* Metropolitan Expressway Public Corporation
* Hanshin Expressway Public Corporation.

United Kingdom

Within the United Kingdom, the land ordnance survey is the main organization for selling GIS-T data and services. It has been mandated by the British Government to help cover the cost of creating the mapping and map data through the resale of this information. As a result it offers it's data on per license basis, along with a yearly maintenance fee. The ordnance survey also has a strategic alliance with Etak.

Ordnance Survey

Ordnance Survey is the national mapping agency, which creates, maintains and distributes geographic data for the entire United Kingdom (UK). Specifically, the Ordnance Survey has created a single line road database code named OSCAR (Ordnance Survey Centerline Alignment of Roads) , which can be used for ITS related applications. The OSCAR database was completed for the UK in 1993 with over 3 million links with a accuracy of +/-3 meters. With similar motif for cost recovery, as it's Canadian Equivalent - Geomatics Canada, Ordnance Survey charges a user fee for all their mapping products. They offer the following products and services.

- OSCAR digital road map databases with scales of 1:10,000 and 1:1250.
- Digital map databases and products: Land Line, Address Point
- Customized product development
- GIS for transport applications

ITS Project Participation

- SCOTIA (Scottish Traffic Information Association) public-private sector initiative involving organizations such as:
  * Automobile Association
  * Confederation of British Industry
  * MVA consultants
  * Scottish Office

- DRIVE II project ROMANSE (Road management system for Europe) designing and building of a geographic information system to integrate traffic data in Southampton as part of the SCOPE (Applications of ATT in Southampton Cologne and Piraeus) sub-project
- Cooperation with Etak, Calif.-based mapping company, supplying road network updates and drive restriction information for use in-vehicle navigation systems
- Map data supply for emergency service applications

Europe

Europe has been identified as a proving ground for GIS-T technology for several years now. There have been many pilot projects for ITS applications which required a great amount of map data to be created for ITS applications. As a result, there are many organizations that not only provide data but integration and software development expertise too. These activities did not exclude the two largest players in the US, Etak and Navtech. Although The EGT/Navtech consortium is for more prevalent in Europe, Etak remains a key player. Details of their relationships with European companies are described below. For further information on other participants, please refer to the appendix.

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Robert Bosch GmbH (Germany)

The Bosch company was first started in 1987, and was exclusively licensed to sell Etak's In-vehicle hardware and software products. After realizing that there was not a lot of data available for Europe in order to use this technology, in 1992 Bosch and Etak signed a data licensing agreement.

European Geographic Technologies - EGT

EGT is selling its map databases to value added re-sellers in four major application areas: automotive, geographic decision support, travel information and automated cartography. EGT supplied the German road database to BMW for use in the Philips CARIN in-vehicle navigation system that is an option in the seven series car. NavTech is the parent company of EGT with Philips having substantial investment in NavTech. EGT's partners and investors include:

* Philips
* Navigation Technologies (NavTech)
* Renault
* UK Automobile Association
* EL.DA
* QC Data
* Institut Geographique National

Navigable database of European road network with a projected completion schedule:

Table 3.0

Germany	available
Portugal	1998
Spain	1998
Norway	1998
Ireland	1998
Greece	1998
Finland	1998
Denmark	1998
The Netherlands	1997
Sweden	1997
Belgium	1997
United Kingdom	1996
Switzerland	1996
Italy	1996
Austria	1996
France	1995

Project Participation

- EUREKA (European Research coordination Agency)
  GENEGIS and SYSCAT projects
- ESPRIT (European Strategic Program for Research and Information Technologies)
  AUTOCAT project

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- Partner in the ERTICO (European road transport telematics implementation coordination organization)
- Database supply for DRIVE II projects:
  - RHAPIT (Rhein Main area project for integrated traffic management)
  - LLAMD (London, Lyon, Amsterdam, Munich and Dublin) integrated road transport environment trials
  - MELYSSA (Mediterranean Lyon Stuttgart site for ATT)
  - PLEIADES (Paris London corridor)

Summary

As identified in the previous chapter, Canada has the makings of a very competitive industrial base for the development of GIS-T applications for ITS. However, factors such as population, government spending, and stronger business cases for its development, has helped to advance development of GIS-T related applications in other countries far faster than here in Canada. Although things like population and government spending will never be overcome, developing a better business case for development can. One factor to building a good business case is the availability of data. Through making data available, companies can build technologies that utilize the information without a concern of coverage, updates or accuracy. Commercial data companies in the United States, United Kingdom, Japan and Europe are currently building those data sets and maintaining them while remaining profitable.

The threat to Canadian industry here is that through breaks given by the governments in other countries, businesses have established themselves to create the appropriate data environment for ITS / GIS-T applications. Some of the factors are as follows:

- The Japanese, through government assistance, have created a central agency for the creation and maintenance of the countries digital road network, which is currently being used for ITS applications. File formats were developed and distributed to all the manufacturers of In-Vehicle terminals, so that they can be made available to all car manufacturers. The result does not necessarily help upstart data companies, but definitely benefits the manufacturers of In-Vehicle map terminals for navigation aids. If these terminals become a industry standard, it will be inevitable that the data standard for JDRMA will also be established as a standard. Advantage Japan.

- The United States government has helped spawn a data industry which also has become a world leader. By eliminating the copyright on all the early version of TIGER (Single Line Street Data) files, companies have emerged through enhancing and maintaining the information. Agreements with local municipalities and other corporate clients have also helped to create a viable business. The real advantage was the fact that these businesses required only the original cost of the government data to get started. Other than operating costs the sales of data, end user sales have produced pure profit. This environment has spawned the two largest GIS-T for ITS data firms in the world (ETAK and Navtech). They have repeated their successes in Europe and are helping to drive the geographic data standards through ITS America. It is not inconceivable that they may address the Canadian market in the same manner, although they will have to overcome the same hurdles mentioned below. The ultimate threat here is their knowledge of the market and ability to address it through partnerships.

As mentioned, Canadian data companies or entrepreneurs that would like start this type of business, must not only overcome a smaller marketplace with lower government funding, but also other factors such as Crown Copyright legislation and competition with other governments trying

to sell their data direct (see 5.1.2 for more details). In a nutshell, the environment to foster the development of data for general GIS-T applications is not currently conducive to a profitable venture for a commercial data organization in Canada. Should any of these companies travel to the states or elsewhere, they will enter the race far behind those that already established themselves.

6.1.2 Governments

Participation of governments is a key to the development of a GIS-T industrial base. Through making data available, establishing standards and fostering relationships with business, they can promote the development of technology. This will especially apply in areas where it is not feasible for commercial mapping companies to create and remarket information, due to market demand and cost. This section will outline the information being created by various government agencies and how they are working to promote the ITS marketplace.

United States

The threat that comes from the US government data suppliers, is the ability to assemble the proper information and make it available to the marketplace. This would incorporate the distribution of GIS information that covers all the primary areas of interest with all relative associated information. The better the base that can be supplied to vendors of this data, the stronger the case will be to use it, as evidenced in the Japanese scenario. Some of the government agencies supplying GIS-T related data are:

US Census Bureau

In terms of maintaining a single line street network for the United States based on current census year, the US Census bureau is the mirror image of what Statistics Canada currently produces for Canada. The US Bureau of Census (BOC) produces a product called TIGER Files. TIGER stands for Topologically Integrated Geographic Encoding and Referencing. These files include a geographic representation of Intersection points with urban address ranges (linking street address ranges to a street location), Zip Codes (Census linkage), Longitude/Latitude coordinates, feature names, political and statistical boundaries.

The TIGER files sell for a very low price on a one time deal basis. Again, similar to the Canadian counterpart SNF files, these files accuracy is questionable. As this is well known, accuracy has not become an issue for those businesses who have thrived through the enhancements they have made to these files. TIGER files are not subject to copyright laws as their counterpart SNF files have been in Canada. This has allowed US firms such as Etak, Navtech and others the ability to greatly enhance the data, in coverage and accuracy, and resell the end product, without excess royalties having to be given back to the government. The result is an accurate, navigation ready, single line network for almost every major center in the United States.

Federal Highways Administration (FHWA)

The FHWA is the equivalent of Transport Canada. They have contracted the Oak Ridge national Laboratory to produce the National Highway Planning Network (NHPN), a geographically based network of all major US highways.

The NHPN has been used for vehicle routing, scheduling, and tracking. It is based on the 1:2,000,000 USGS Digital Line Graph (DLG) files.

United States Geological Survey

The USGS is the agency equivalent to Geomatics Canada, and responsible for the gathering, analysis, and presentation of information on U.S geology, water resources, and topography. The USGS produces the U.S National Digital Cartographic Data Base (NDCDB) and has been active in the creation of spatial data standards in the United States. From this database the USGS produces a product called the Digital Line Graph (DLG) which includes geographic information on roads, Railroads, bodies of water, political and administrative boundaries. This information is available at 1:100,000

UK, Europe and Japan

As mentioned above, both the UK and Japan have a single national organization that provides a national road network. Other countries in Europe also have a central mapping authority that handles the creation and maintenance of the road network. One of these is the Institute Geographique National (IGN) (France), which has also created a tight relationship with EGT. For more information on UK and Japan refer to above section listed within the commercial data offerings.

As mentioned, governments have played a very key role in the development of intelligent road network databases. The threat from foreign governments surrounds the conditions through which they supply data. In most cases, information is sold with a one-time fee opening the door to resell enhanced data etc. However others, including Canada, require a copyright fee on all data sold. This, in most business cases, pushes the price over what the market will bear. This business environment does not lend itself well to the development of the data business in Canada. It also carries on through to the development of the technologies that would utilize it, and thus ITS development in Canada.

6.1.3 Data Standards

Within the GIS-T arena there is a large quantity of mapping procedures, applications and products. As such, the creation of standards for Geospatial data, may mean different things to different organizations. Many times the topic of GIS standards turns into the equivalent of the theory of relativity, incorporating many different aspects from many different views. Although these issues can be very complex, establishing some sort of data standard will assist those organizations unable to incorporate certain types of geographic data as a part of their solution. To date, much of the information has been created in a format that is only accessible by the devices that are allied, or owned by the data vendor. It is these alliances that create a better business environment for the development of this technology. Creating well publicized data standards, can help overcome strong "Total Solution" threats from other large competitive companies. The lack of data standards for GIS-T data is a threat to the development of smaller business that require the ability to import data of all kinds for the success of their technologies.

To date, standards definition has primarily been driven by the governments. Depending on ones perspective, standardization can be a good thing or a bad thing for the development of ITS applications. As an example: The Japanese, through the joint government/industry committee JDRMA, created an agency to formulate a map data standard, and control all the mapping activities within the country during the 1980's. As a result, the standard fostered the development of in-vehicle navigable units, and allowed the ITS industry in Japan to advance very rapidly. Not only did the Japanese industry boom, but foreign companies wanting a copy of the data would be charged substantial fees due to the fact that they were not part of the consortium. Also through

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the consortium, hardware formats were standardized for the storage of digital map data. The result was a significant demand for navigable road products which does not exist in Canada.

Within the US there has been extensive work done on the definition of a navigable map database standardization. Although good work has been done, there still exists no published standard. As a result the efforts of the private companies will ultimately define a standard that be proprietary, creating profits as the demand for this technology increases.

There are many countries in Europe that also are interested in map standards. They too, have diverse interests between countries. Some countries place a great amount of emphasis in obtaining revenue from their mapping activities, while others do not. The result creates a lower demand for certain mapping products over others. Each country then pursues their own mapping standards, creating a dissension among the countries. Again, the private data companies win, as they create the market for the data in their own format.

The following is a summary of some of the programs now in place for the standardization of mapping data:

United States

The common thread through all the following organizations, is that they will be recommending the SDTS format as the single standard. This standard is being developed by American Interests for the US and the rest of the world.

Federal Geographic Data Standard Committee

This committee is attempting to define and promote the National Geographic Data System, through the development of profiles for the Spatial Data Transfer Standard. This will include the evaluations of spatial data definitions and standards of other organizations such as ITS America. ITS America will help with the standardization of digital map data as it pertains to Transportation management and in-vehicle navigation systems. A draft report currently exists dated April 3, 1995, defining the Transportation Network Profile as a part of the SDTS standard. In an effort to satisfy the link to international data standards, there has been some modifications to allow for ISO 8211 attribution and links. It is unknown if it is in full compliance with the ISO standard.

U.S. GIS-T/ISTEA Pooled fund study (Public/Private Partnership)

The purpose of this study was to develop GIS-T server net prototypes supporting the ISTEA requirements for transportation planning and monitoring systems. The objective can be further qualified to:

- Create integrated information system architectures and design requirements encompassing transportation planning activities and data.
- Encourage the development of functional GIS-T server net prototypes. These prototypes will be developed by the private sector partners sponsoring the study.
- Demonstrate multiple information systems implemented in a server net environment.

ITS America

ITS America has taken the role of initiator in the creation of a set of Standards for the National ITS Architecture. They have created a primary committee to examine Standards and Protocols. Within this S&P committee sits a sub-committee on Map-database and information systems. The present

result has been the investigation into the feasibility of using SDTS or GDF as a selected standard. It is believed that SDTS - Transportation Network Profile will become the ITS exchange format of choice upon closer review.

Society of Automotive Engineers (SAE)

SAE's ITS division oversees a number of committees, among them the Map database standards committee. With the assistance of FHWA and Oak Ridge national Laboratory ORNL, they are currently working on a standard based on either link-ids or coordinates. This will help define the quality and content of street databases, allowing the user to evaluate a dataset to see if it meets their specifications. The chair of this committee is T. Russell Sheilds, Chairman of Navigation Technologies Corp.

Europe

Slowly becoming a standard throughout Europe is the Geographic Data File - GDF Protocol. This format was first generated by Philips and Bosch in 1986 to support their efforts in the car navigation business. As ITS becomes more prevalent in Europe, this format also gains acceptance. It consists of three elements.

- Specification of Data Content
- Specification of Data Acquisition
- Exchange Format

GDF is currently being evaluated for incorporation into the National ITS architecture through ITS America.

It was once said that the greatest thing about standards is that there are so many of them. The same holds true for GIS-T standards. As every country is currently defining their own data standards for Linear Road Data, it appears that file compatibility across countries may be a problem. The loser in this scenario is the user who would like information from an expansive set of data. The winners will be the companies who can bring the data together from multiple sources and resell it in a format compatible with the viewing device. This capability is only available via a very few select firms within Canada, Europe and the US.

6.2 Research and Development

The area of ITS Research can clearly be defined as an area that can be a threat to Canadian interests. With the assistance of federal grant programs and the shear promise of this evolving technology, many Universities around the world are starting programs dedicated to ITS. The FHWA helps fund Universities for study programs in ITS, and has set up the ITS centers of Excellence program, which includes Michigan, Texas A&M, Virginia Tech and The University of Minnesota. Transportation research Board along with other private US organizations such as Rockwell also helps fund ITS developments. Of all the following universities having an ITS program, there are very few that have specified the research of transportation related geographic data as a part of their curriculum, they are:

- New Jersey Institute of Technology
- Pennsylvania State University
- Purdue University
- Texas A&M University
- University of Arkansas

- University of Massachusetts
- University of Michigan
- University of Southern California
- University of Nevada
- Virginia Tech
- Wayne State University

In Europe:

- University of Birmingham
- Helsinki University of Technology
- University of Leeds
- University College London
- University of Westminster

In the US, the federal government also sponsors much of the research of many National Laboratories like the Oak Ridge national laboratory - ORNL, which develops the NHPN for FHWA. They also have had a great amount of input on things as Transportation GIS Standards. Canada currently does not have such a relationship with similar institutions.

Private Industry also helps fund Research at US and European based Universities. Companies like Rockwell and Navtech have funded studies on GIS-T for ITS at various universities.

There is currently a minimal number of known ITS business or government alliances, established with any university in Canada. As a result, there will be little development of knowledge, expertise and product for GIS-T, which increases the improbability of any businesses evolving from academia. Often the latest advance in technology comes from fresh young minds. Without an investment here, Canada will always be second to the US.

6.3 *Systems Integration and Software Development*

Another area that is very significant within the GIS-T portion of the ITS business is the consulting and software development side of ITS. As mentioned above, the strengths of some of the vendors of Geographic viewing technology is the fact that they supply data and integration services with the product. Since data is more readily available in other parts of the world, the development of these technologies has also been primarily in other parts of the world. This combined with funding for Research and Development, and a thriving defense business, has really helped the industry move ahead elsewhere.

As mentioned earlier in the needs section, the centerpiece that makes the technology work is the algorithms and intelligent software to do things like map matching and routing. With the exception of the Canadian company GIRO and a few others, we are weak in this area. The US and Japanese have dominated this component of GIS-T, and have ultimately set the standard for most of the commercial devices available for applications such as Map Matching and In-Vehicle Navigation. In a lot of cases, there are heavy copyrights imposed on these technologies, which has additionally helped specific vendors to obtain a market edge.

All is not lost, although this specific market is still an emerging one. Newer hardware technologies have provided an environment to be able to build better and faster software for doing intelligent decision support. Vendors with a market lead, could lose it very quickly given a level playing field. There are many researchers and consultants in Canada who could thrive in this area given the proper development environment.

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6.4 Foreign Policies / Programs

In general, any foreign policies that support the development and expansion of a business sector becomes a threat to other countries' attempts to bolster their own industries. When we look at ITS in Canada relative to expertise in data standards and policy development we should consider our experience base as being in the middle of the pack behind the U.S. and Europe.

In regards to data standards, the U.S. and Europe appear to be ahead of Canada in the ITS area (e.g. substantial support and leadership from ITS America). However, in regards to standards for geospatial data (the foundation for many ITS applications), Canada continues to be a leader in moving that standards agenda forward which includes the development of the DIGEST data standard (endorsed by NATO) and our leadership with the ISO TC 211 technical committee on geomatics standards.

In the policy area, Canada is competing against the U.S. which supports the ITS movement and has the critical mass needed to make things happen. With the recent advances in the union of Europe, they now have the opportunity to utilize this mechanism to create strategic partnerships (a potential "Information Society") among already strong countries in ITS. Although Europe has potential, the creation of these strategic partnerships would appear to be in its early stages. Offsetting the strengths of the U.S. and Europe, Canada has the benefit of having experience in common law for crown copyright and freedom of information together with viewing data as a source of government revenue. Establishing ITS from ground zero in the global market will require the type of varied perspectives and experiences which Canada has related to data policy formulation and implementation.

Almost all of the policies that effect competitiveness, originate from the government. They are often established as a part of a larger program to create openness or help develop an industry. In the context of ITS there are a couple of policies that may effect the development of this marketplace. They are:

Revenue Generation

Although this is an unwritten policy, many of the governments are moving in this direction to help cover the cost of data creation and maintenance, eliminating the cost to the taxpayer. Since any method for revenue generation is never currently frowned upon, eliminating it to pursue Industry development would be very difficult.

Often the problem lies in the way GIS-T data is sold. Many times government agencies charge for data because they know that someone may buy it, and one dollar is better than no revenue at all. This coupled with a decreasing tax base and workforce, also increases pressure on government to generate their own internal revenue flow. Also, governments have become more protective of their data assets and do not distribute them freely, internally or externally, without a royalty charge. thus creating problems for other purchasers of the software. As a result, data that was created originally for a specific purpose within the ministry, may be impractical for use outside government.

This scenario occurs in the GIS for ITS applications arena, where much of the data has good geographic coverage, but no one government can supply a complete dataset. This would make it impractical for any usable ITS application. This example is true in Canada for the ITS/GIS business. The coverage is fairly complete, but not one government department can supply a complete data set at the scale required for ITS applications. In order to create a complete set that may be usable, information must be gathered from the various levels of governments and be

amalgamated. Since all levels want their revenue via crown copyright, the feasibility of this ever happening is slim. Final selling price would be far to high and unaffordable. It is because of this fact, that this policy becomes a threat to the Canadian business.

Crown and Data Copyrights

Currently data produced by all levels of government within Canada are subject to Crown and Data Copyright legislation. This legislation restricts the redistribution and enhancement of the data for activities other than immediate use, without an agreement for royalties. Thus any company that enhances data for resale would have to pay the crown for every copy sold. As described above, it would take multiple data sets from several government agencies to complete something appropriate for ITS applications. The marketable end product would push the number of royalties required higher, resulting in an astronomical end user cost.

As mentioned within Section 6.1.2, the United States does not institute crown copyright, which has helped to foster the development of the ITS and GIS-T business. This factor has benefited the American data and GIS-T technology vendors get established within the US marketplace. In the cases of ETAK and Navtech, it has helped expand into Europe based on the knowledge gained through the US experience. The end result is still a revenue stream that helps create more data and assists the development of accompanying technologies (i.e. In-Vehicle terminals). As a result this is definitely a threat to the Canadian GIS-T business.

As US government organizations move more towards cost recovery, along the same lines as Canada, the prices of these data sets will increase. Should this occur, the large navigable data organizations will win, due to their superior product and better capability to maintain the information. The threat here is the formation of market that is driven by a limited number of vendors.

Within Europe, there has been much discussion regarding "Information Society" and economy but it appears to be in the early stages. As observed, this may be very difficult to enforce as all the various countries have varying views on this subject centered around their own copyrights and cost recovery options.

6.5 Assisting Organizations

ITS America

ITS America is the leading privately led organization for ITS in the world with the bulk of it's members originating from the United States. This is not unusual, as this is where the great majority of ITS related dollars are being spent. However, as with any private industry organizations, many of the views are based on the those of it's membership. Although, ITS America's mandate is to best serve the ITS industry as a whole, the membership is primarily American, which will also serve American interests. Add this all together with the fact that most of the members are currently working on American projects, which raise US related problems i.e. protocol and compatibility problems.

The threat of ITS America it's ability to resolve problems that are specific to Canada. This is no discredit to the organization, but only fact. As Canadians are only a minority portion of the membership, focus on their associated problems may be minimal. From a pure business perspective for Canada, and without a Canadian based organization, there will be no medium for communication and partnership development, something ITS America has with US members.

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Until ITS Canada is revamped, the US organization is still an excellent medium for issues that pertain to bridging existing technologies and bridging US based compatibility issues.

Summary

Overall, there are many threats that may effect the development of GIS-T technologies for ITS applications. Of them all, only the fact that Canada has a smaller marketplace and lack of government spending, may be insurmountable to allow local application development. Issues like data standards, R&D programs, Crown Copyright, Public Private Sector Alliances, Multi-Source Data Compilation must be addressed before Canadians can compete for GIS-T related ITS business within Canada and Abroad.

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Although the ITS marketplace has been fairly well defined to date, there are many opportunities that can be identified for Canadian Industry within the GIS-T application area. Although the golden ring may ultimately be beyond Canadian borders, the methods for success with other firms in this marketplace, originate in their own backyard. Many foreign firms that are currently selling abroad have definitely developed their expertise through the implementation of applications locally. With the help of some suggested changes and actions in the next section, the following opportunities can be developed. These opportunities will be based on the premise that Canada is:

- A world leader in the area of geomatics, specifically data collection and development standards.
- Technically one of the best countries in the world for software development.
- One of the best countries in the world for technology leadership
- High Quality of Education.
- Known for it's Civil Engineering talent
- Has one of the most integrated ITS sites in the world - Ministry of Transportation Ontario
- One of the best mapped countries in the world
- Has a lower monetary exchange rate - in some cases can make Canada more competitive.

Some specific opportunities as a result of this reputation and capabilities are:

7.1 Systems Integration and Software Development

The market potential in this area of development is very high. As this is the core of the intelligence within the ITS industry, new developments can make or break a strong marketable application. As mentioned in earlier sections, Canada has developed some key component technologies like specific algorithms for routing. Within the GIS-T context many of these smaller niche applications have attempted to develop other technologies of their own i.e. graphical interfaces etc. to combine into a final application for ITS. Not having the expertise in the complementary technology has actually hurt the final application of the original one. In many of these cases, there was another complementary technology available that would have made the application far more marketable. In order to make current technologies more marketable, partnerships may increase sales ten fold. This may be propagated through the readoption of ITS Canada as a medium through which partnerships can be built.

Along the same vein, research accomplished at universities like University of Montreal and Ecole Polytechnique amongst others, should be showcased so that other developers may pick it up for inclusion in to their products.

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To date, this has always been talked about as a potential application, but there has not been anyone who has implemented it. M3I in Quebec has experimented in this arena, and have had some success in the local market.

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As the internet becomes more popular as the medium of choice, also does the opportunities for the marketplace. ITS is no exception to this rule. The challenge is to build a GIS application that will link to other information on the Internet. As mentioned briefly in previous sections, internet browsers currently support only raster type graphics with hooks to other data sources. Computations have to be done remotely for the user to get any benefit from a sophisticated application. Often these calculations can take forever making the application unusable.

The challenge is to link mapping information to a local software engine that can take the information and transform it into a usable product quickly. The business opportunity is to sell the pieces of software for the processing.

There are currently many startup companies in the United States that have created an information service with live links to the local Traffic management offices. In Boston and Los Angeles, companies are using the internet to provide a service to subscribers, that contain a map showing colour coded roadways based on congestion level, updated every five minutes. Given that in congested cities, travel time is a large part of the day, a service like this is necessary.

As Canada is currently outfitting itself with high speed fiber optic cable for the Internet, and local cable companies are planning to provide service within the home in the next year, these applications could produce high demand, very quickly.

7.4 Commercial Vehicle Operations

Similar to Emergency Dispatch, there is also an opportunity to provide a commercial vehicle system which integrates a map component to calculate mileage's, vicinity queries etc. Vehicles could also be dispatched based on current road conditions, vicinity of caller and destination. Although this market has recently been identified as high growth due to the reduction in price of GPS receivers, it will become very competitive very quickly. Courier companies, Waste Management firms, Disabled Transit, Cab Companies, and Pizza Delivery stand to save a great deal of money by implementing this type of technology.

There are currently only a few companies in this arena. Innovation with new technologies will be essential to success here. Other technologies such as Internet links, GPS, Dynamic Map updates etc. will also help to produce a unique competitive product.

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7.5 GIS-T Data Providers

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The opportunity here is for Canadian data providers to get together with government and overcome their differences on issues like Crown Copyright, Royalties and cost of data. The result will be the creation of a navigable database that will foster the growth not only of this marketplace, but that for Navigation / Location tools as well. A navigable map base will benefit the producers of the In-Vehicle and portable terminals.

The business will include the supplier to maintain and enhance a navigable database for use within transportation (ITS) related applications. The data can also be used for address matching, the simplest form of referencing other electronic mapping data. Address matching is also recognized as the most inexpensive way to implement a GIS.

Once the database is in place, the maintenance of the data is the next most labour intensive activity. Subscriptions to the data will be paid as a maintenance fee and updates will be provided periodically (Quarterly). This can be done very inexpensively via CDROM, as the cost to produce is very low. Currently users must purchase the appropriate maps for their terminals via a subscription or local retailer. Manufacturers of vehicles may sell the subscription with their cars, or viewing devices.

Firms that wish to survive in this industry must be willing to expand their clientele outside of the ITS arena. Although some firms in the US and elsewhere have survived by solely marketing to navigation type companies, a pure data supplier cannot survive on just ITS alone in Canada, due to it's market size and revenue potential. Although competitive firms in other countries have had the luxury of not having to deal with Crown Copyright to achieve success, it will have to be dealt with here. Irrespective of any of the recommendations made in the next section being acted upon, the issue of pricing will be front and center in order to develop a business case. The market will be defined by what the customer is willing to pay for the information. If all the stake holders want too much for their share of the end product, it will become too highly priced. Some other recommendations for success under the current industry constraints are:

a. Establish partnerships with the various government agencies and establish marketing rights for their data. Bring the multiple data sets together into one comprehensive environment, enhance and package it for resale directly and/or establish a dealer channel for distribution.
b. Governments are often looking to offload expenditures. The opportunity would be to offer data maintenance services to the data originator (government or large private firm) with other enhancements at a reduced cost. This will create a business case that may seem viable for organizations looking to cut costs.
c. Obtain an agreement to modify and resell with royalty.
d. Make a deal with other data suppliers for a partnership.
e. Enhance the data by adding other information. Parcel information, Tourist locations, GIS functions, other software etc.
f. Establish partnerships with other technology vendors to bundle data, for a total solution. One example would be to team with a In-Vehicle terminal manufacturer.
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In the future, the control of such data will be very lucrative as applications that require intelligent map data (In-Vehicle Terminals, Internet and Kiosks) become more widely accepted. Unfortunately many developers of these technologies are waiting for the data to be made available, while the data suppliers are waiting for the technology. Hopefully, something can be done in the near future (Recommendations next section) to make both these lucrative business opportunities viable.

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Canada is already renowned for it's work in the Geographic Data Standards area. We have played significant role in the definition of the DIGEST, SAIF and most recently TAC Digital Road Network data standards. As a result, Canada has the opportunity to use it's expertise in geomatics standards as a base to launch ITS standards development. However, it must have an approach which is formal, but not so formal as to bury the real issue in process and bureaucracy.

The opportunity is to define and put into operation a working standard that is accepted by all. If this is a standard that has been previously defined, like the Road Network Standard currently being done through the SDTS initiative sponsored by the Federal Geographic Data Committee, then let us adopt it and make it work with other Canadian technologies. Establishing a standard for the interchange of Road network information will allow multiple vendors the ability to transfer and use this information as a part of their core technologies. Making data available in a common format, will assist with the development of complex multi-component technologies by Canadian firms.

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Based on the premise that a picture (map) is worth a thousand words, the concept of digital mapping as a way to interface to data, will always be appealing to any end user. This concept is also appealing to businesses wanting to create a product that sells. Graphics helps sell products that may otherwise be very mundane. GIS-T data and software solutions provide an excellent way of evaluating on-line road ITS information. As technologies emerge, so will the requirement for GIS and digital mapping information. The opportunities outlined above, are only a start.

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8. Conclusions / Recommendations

Based on the information that has been identified , we can now draw some conclusions on what must be done to make the Canadian GIS-T market for ITS applications successful. The following identifies a summary of Canadian Strengths and weaknesses, the current outstanding issues, and game plan to overcome them to achieve the aforementioned goals.

8.1 Canadian Strengths

As identified by many, Canada has an exceptional reputation when it comes to geographic related applications.

The government agencies in Canada have the largest GIS data depositories of any known in the world.

The commercial mapping companies in Canada are known world wide for their excellence in map creation and ability to prepare information for GIS.

We have some of the strongest knowledge in the world on GPS location devices, as well as it's uses with mapping technologies.

Several firms have created innovative uses of routing algorithms with digital mapping technologies.

Some of the most advanced Computer Aided Dispatch sites in the world utilizing mapping technologies reside in Canada.

All provincial ministries have implemented some sort of digital road network as a part of their highway infrastructure management initiatives.

The Ministry of Transportation - Ontario is known world wide as one of the leaders in the implementation of ITS. Many consultants who have worked on the MTO initiatives are also identified internationally.

8.2 Canadian Weaknesses

With strengths there must be weaknesses, the Canadian industry for ITS applications is no exception. They are:

Due to the lack of available GIS-T data that can be used for semi-navigable applications, there is no national road database. There is currently no initiative to create this database, as well.

Data copyrights by various organizations have made the information too expensive to buy for any ITS application. This has not promoted the development of map display devices within Canada. All known current devices originate from Japan or the US. There is some interest by some companies like MicroSlate (Montreal) but due to the unavailability of data there is no demand.

There is no development of research initiatives for GIS-T within ITS applications in Canada. Joint partnerships have been developed by US private organizations and other Universities to promote research and development within this Industry sector.

As of this report, there is no recognizable organization / association assisting with the development of the Industry in Canada. i.e. ITS Canada. As a result, there is no medium for Canadian companies to establish partnerships or review standards etc. Although ITS America can help Canadian firms in a general sense, country specific issues may be overlooked due to the size and wealth of the US membership. .

There is currently a lack of funding for ITS initiatives, due to the downsizing of the provincial and federal governments. This has affected the development and deployment of the technology and industry through practical implementation. On the other hand, the U.S has recently announced the continual funding of the (Intelligent Transportation Infrastructure - ITI) program. Effectively, it seems that the U.S is maintaining ITS activities while Canada is cutting back.

There is a lack of standards for GIS-T data for ITS applications. Although this is a worldwide issue it effects Canada through the acceptance of proprietary data formats. Data can only be used by devices that can read a specific format.

Lack of strategic alliances. The Canadian ITS industry in general lacks the number of alliances to be able to deliver complete solutions. This applies specifically in areas where multiple technologies work together to define a complex ITS solution.

Canada has limited experience implementing GIS-T related technologies for ITS.

8.3 *Current Issues*

There are currently five primary issues that prevent Canada from being successful in this market. They are:

1. ***Crown Copyright, and 2. Cost of Data***

   The Crown Copyright legislation prevents the government from distributing freely the data it creates. Users do not have the ability to recreate or modify the information without written consent from the originating body. This policy along with the price of the data, has hindered the use of this information. Data suppliers have traditionally stayed away, as it has been financially unfeasible to make this data usable along with profit. A small market demand and low level of accuracy for the available data sets, also complicates this matter further.

   Furthermore, this same legislation prevents the government from sharing its data with other jurisdictions such as the US and Mexico. This complicates the issue to do with compatibility with the US and Mexico, who are willing to give Canada their data for free in an open format. The plan being to promote NAFTA for the Transportation industry.

   3. Data Sharing

   Data sharing is also an issue that prevents the development of this Industry. As mentioned earlier, Canada is the most mapped country in the world. This also holds true for Transportation data. With the recent downsizing of all governments, and the emphasis on revenue generation, government departments have continued to build their own data sets for their own purposes. Along with the need to balance costs, they have attempted to turn themselves into a sustainable entity through the resale of data. The monetary transfer has not only been applied to private industry, but also between government departments as well. As these other government departments have the same monetary challenges, information is not

shared. The result is silos of information, with duplication of effort between ministries. While this goes on, there is only superficial cooperation that does not foster teamwork, nor the creation of marketable database for ITS applications.

4. Data Standards

Although Canada has made great strides to establish Geographic Data standards there is not one that has been accepted for GIS-T / ITS use. With the recent creation of the GIS Transportation Network Data Standard by the Transportation Association of Canada, a standard has been created to help assemble a common understanding of the information and formats required for all related applications. The only problem is that this standard is not recognized by anyone as being complete. BC and Saskatchewan are observing SAIF as their standard, while the federal government recognize DIGEST, with others using SIF. With so many file formats dictating various levels of content and accuracy, it is very difficult to integrate GIS functionality into ITS applications from one region to the next. ITS integrators would also have to obtain information from multiple sources and create a translator for each database. Although the task is not impossible, it is very cumbersome and costly.

Both the United States and Europe are working in opposite directions with SDTS and GDF. While these formats are somewhat different, at least they address the needs of ITS and transportation. These will eliminate the need to translate and clean the information each time an individual application wishes to use GIS data. In the end, there is a strong requirement for a common file format, so that all technologies can be developed equally without having to incorporate so many file formats.

5. No Regulatory Body in Canada to Recommend Actions or Foster Partnerships.

This issue goes along with the above. Without a regulatory body, a champion of the collective ITS cause can be created. Policies like GIS-T Data formats cannot be examined and tailored to Canadian concerns . Currently, there is no equal representation on other committees such as ITS America's National ITS Architecture. Without this representation, Canada will not be able to influence the direction of the industry. As a result, standards which work well with existing technology will dominate. By creating an Association / Regulatory body, Canadians may collectively have a voice on these committees that may be heard above participating individually.

A mechanism for fostering of partnerships must also be available. A Canadian ITS regulatory organization will be able to promote the industry as a whole, while fostering partnerships amongst Canadian technologies to be able to compete in the global market.

8.4 Recommendations for Success

The recommendations for the future success of the GIS-T market for ITS applications is quite simple. Since GIS-T is only a component of the bigger ITS picture, some overall actions should be made to move the whole industry forward. It is unclear at this time as to who may take the action items for the future. They are general recommendations:

- Government needs to provide seed money to create some momentum in the ITS industry. Planned ITS initiatives in the major metropolitan areas such as Montreal, Toronto and Vancouver must move ahead in order to help develop Canadian talent locally. Priority should be given to business cases that clearly show both short term and long term pay back. This will help create repeatable business opportunities for Canadian companies abroad. Priority should

be given to firms that share risk for the development of these applications. This would also ease the cost of implementation.

- ITS Canada should be supported by government participation, and the organization should be representative of the industry at large (i.e. ensure all stakeholders have an opportunity to participate and benefit from any strategic plan and implementation)

- Don't re-invent the wheel; utilize the work done by ITS America, Europe, the ISO, etc. Technology standards (i.e. data or electrical standards) developed by other organizations should be adopted and enhanced for the local market. This will ensure system compatibility abroad while creating a unique format covering local issues. Coordination, cooperation and good communications amongst the various Canadian firms, directly or via a regulatory body, are fundamental for any chance of success in the standards arena.

- If Canada is weak in any given ITS application area, strategic alliances with those who have the expertise should be considered. An international consortium of key ITS firms (including Canada's) could be in a position to dominate the global opportunities in any ITS market. Keeping touch with advancements via association memberships and industry publications will be essential to choosing the right partner.

- Foreign firms that encourage the development of other ITS technologies, should be potentially assisted in order to advance development of complementary applications. i.e. Cooperation with Navtech technologies in order to establish a navigable road network in Canada. This would help promote ITS in general, through the creation of applications which use the data.

- The assessment and consolidation of ITS and related standards in Canada is imperative. Committees need to be established in order to consolidate all the different technologies standards into one document. This initiative should coordinated with ISO, or via the work being done with ITS America.

Through identifying the issues mentioned in Section 8.1, there are five primary steps that need to be undertaken to ensure success of GIS-T for ITS applications. They are:

1. ***Create a National Digital Road Map at an accuracy meeting ITS application needs, and have it administered through one body, with input from all the stakeholders.***

   The National Road Map must be made to navigable accuracy, and cover all known roads, highways and streets, at least within major urban areas. The stakeholders will be all government agencies that utilize a street network of any kind.

   This activity will require the investigation of the various sources of the data across Canada to confirm the feasibility of such a map product. This could happen as a Public/ Private venture where the end result benefits Canadian business. Recommendations should cause the least amount of impact on the current working environment for government, but should foster the development of the industry. Other issues that will have to be addressed as a part of this initiative are:

   - Could this database be used by all government agencies requiring this type of information for own internal activities.
   - Could this function be outsourced eliminating the overlap within existing government departments.
   - Can this product satisfy other sectors / markets.

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Transportation and Infrastructure Engineering
Intergraph Canada Ltd.

- Does it fit within the overall framework of government geographic data.
- Can the creation of this database increase and /or sustain the revenues already obtained through the resale of similar government data.
- Does this amalgamation eliminate the creation of redundant data.

Suggested Action Plan:

Commission a study to examine the feasibility of creating a National Digital Road Network, examining the potential for reducing duplication at all levels of government and discuss the possibility of a Public / Private consortium to administrate it. The report should also examine ways through which the government can reduce expenditures, and how it can eliminate it's involvement over time, while ensuring it keeps the data required for key internal activities. i.e. Maps for the promotion of the NAFTA agreement. The study should also show how governments can focus on achieving revenue goals to sustain maintenance and development of the database. Crown Copyright issues must also be addressed in this report as identified in item #4.

2. ***Create a Standard Exchange through which ITS information can be distributed nationally.***

In addition to the initiative above, there needs to be a data standard through which the above national dataset can be administered. This activity will require a review of existing policies created for GIS-T data standards, including outside Canada. Other activities include:

- Define the various organizations involved in standards development and develop a flow chart indicating the necessary linkages and interactions among the players
- Establish a process for defining user needs and developing data standards to address these needs
- Establish a process for doing a standards inventory and setting up a clearinghouse of existing standards, maintained by one agency. ITS Canada ?

Suggested Action Plan:

This activity could be handled through one of the sub-committees established by the board of ITS Canada with help from ITS America.

3. ***Recognize ITS Canada to help lead the development of an ITS industry in cooperation with Governments in Canada.***

Reestablishing ITS Canada would promote the general development of the ITS industry in Canada and help address the issues from a Canadian perspective. It can be created as a medium through which Canadian firms may operate, evolve business alliances and ensure compatibility with the rest of the world. This would include establishing working groups to propose and advise on current issues for strategic planning.

Suggested Action Plan:

The roles and responsibilities and organization of ITS Canada is currently under review.

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7070 Mississauga Road
Mississauga, Ontario. (905) 812-9755
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Transportation and Infrastructure Engineering
Intergraph Canada Ltd.

4. ***The Government needs to review its data access/ownership policies and programs to assess to what degree they may hamper the quick start required for the ITS industry in Canada.***

   As established during the report, one of the largest issues impeding the development of the GIS-T and ITS marketplace is the current data access/ownership policies within all levels of government. As there is no National Digital Road Database that has been built to navigation specifications, the ability to develop and implement applications that utilize a cohesive mapbase are impossible. The feasibility of this action hinges on the ability to change , eliminate or make exceptions to the Crown Copyright.

   Suggested Action Plan:

   Set up a committee to review the Crown Copyright issue and examine how it can be changed to foster better cooperation between departments, and assist in the creation of a viable data industry for ITS applications. Through lowering the Crown Copyright barrier a GIS-T database can be created. This may even eliminate redundant data collection that may be occurring between government departments currently.

5. ***Establish a program to help the research and development of GIS-T for ITS applications.***

   Due to the fact that other countries are heavily supporting their ITS Industries through University research programs, Canada must keep up. As this industry is constantly changing, having young talent constantly researching new technologies is very important to future growth. Since Canada are already the leaders in Geomatics, there is no reason private sector companies could not become the premier developers of such related technologies, through partnerships with funded universities and colleges.

   Suggested Action Plan:

   Establish a university liaison group through ITS Canada, in order to identify specific ITS technologies that need to be assisted.

   Get private sector firms to invest in university programs developing applications for certain areas.

   Find out who is involved in funding university research within the various governments and lobby to get funding for ITS.

Appendix A: Bibliography

1. Paul Jackson, 1996, Group Differences in Ability to use Verbal Route Guidance and Navigation Instructions, Centre for Transport Studies, Department of Civil Engineering, Imperial College, London.

2. Larry McPherson, 1996, A GIS Application Used for Highway Safety Studies, AASHTO GIS-T '96 Symposium.

3. John H. Ganter, Cecil W.H. Goodwin, Demin Xiong, 1995,The Open Geodata Interoperability Specification (OGIS) as a Technology for Geospatial Transportation Computing, Geographic Information Systems for Transportation Symposium (GIS-T).

4. Larry W. Minor, Michael Baker Jr., 1996, Issues and Strategies in GIS/GIS-T Data Access, GIS-T '96 Symposium.

5. David G. McKellar, 1995, Digest - A Multinational GIS Transfer Standard, Defence Geomatics, Canada

6. Dr. Edward. J. Krakiwsky, 1996, Assessment of Positioning and Navigation Technologies for Intelligent Transportation Systems, Intelligent Databases International Ltd.

7. William F. Johnson, 1995, Intelligent Transportation Systems in Canada: Current Priorities and Future Directions, The Second World Congress on Intelligent Transport Systems '95, Yokohama, Japan.

8. John A. Volpe National Transportation Systems Centre, 1995, Transportation Network Profile, Federal Geographic Data Committee.

9. Bo Guo, Allen D. Poling, Mark J. Poppe, 1996, GIS/GPS in Transportation, Real World Experiences, Lee Engineering Inc.

10. IBI Group, 1996, ITS Sensor Technologies - System Definition Technical Memorandum, Industry Canada, Transport Canada.

11. Joe Stapleton, 1996, "Lessons-Learned" In Atlanta's New Advanced Transportation Management Center,
12. ITS Online.

13. Papacostas, 1996, GIS Application to the Monitoring of Bus Operations, Department of Civil Engineering, University of Hawaii,

14. John Cartwright, February 1991, Project Pathfinder- Roads to the Future, GIS World Inc.

15. Liz Skinner, April 1995, Itisn't Your Father's Oldsmobile Anymore, Washington Technology.

16. Jeff Shafer, Peg Herbst, 1995, CompuServe Offers Travelers A Better Way To Go, CompuServe.

17. Peter Fabris, 1996, The Highway Patrol, Traffic Management.

18. Paula Finnegan, Amy McKibbin, 1995, World's first and only Voice-Interactive Car Navigation System now available to consumers, Amerigon.

19. Christine Peterson, Debbie Olson, 1996, Going Global: Working Smarter in the ITS Marketplace. ITS Quarterly.

20. John B.L. Robinson, Robert C Ridley, 1994, A Strategic Plan for the Development of IVHS in Canada TP # 11885, Transport Canada, Policy and Coordination Group.

21. Emelinda M. Parentela, Shashi K. Sathisan, 1996, GIS - Based Allocation of Emergency Response Units along a Transportation Route, GIS - Based Allocations of G.A. Transportation Route.

22. Federal Geographic Data Committee, Ground Transportation Subcommittee, 1993, Federal Agency Needs for Ground Transportation Networks and Network Attributes, FGDC.

23. Bruce Abernethy, James Gunn,1996, A Different perspective on National Architecture, Traffic Technology International.

24. Jackson, 1995, The effects of receiving additional information upon ability to remember routes: summary of results, University of London Centre for Transportation Studies.

25. Brian W. Cromie, 1995, Electoral Geography Data Base Project, Elections Canada.

26. John H. Ganter, Jonathan W. Cashwell, 1994, Display Techniques for dynamic Network Data in Transportation GIS, GIS-T '94.

27. Haig Simonian, Boom in satellite navigation for cars, Motor Industry Correspondent, Financial Times (U.K.)

28. Russell Shields, 1995, ITS Information for Industry Canada Studies, Navigation Technologies Canada, Inc.

29. Power & Associates, 1995, Vehicle Navigation Systems Technology, The Power Report.

30. Tim Barkow, 1995, Ground Truth, Never get lost again, as geographic information systems usher in the era of intelligent transportation technology - smart cars. Wired.

31. Molly Trudeau, At Last A GPS Experience, Land Navigation.

32. Paul Pihichyn, 1994, User Friendly - Software eliminates vacation nightmares, The Globe & Mail.

33. IBI Group, 1996, ITS Display Technologies, System Definition Technical Memorandum, Industry Canada, Transport Canada.

34. Arjan Chandan, 1995, Proposal for a Road Map for the Development of an ITS Industrial Base in Canada, Aerospace and Defence Branch, Industry Canada.

35. Arjan Chandan, 1995, ITS Related Activity, Transport Canada and Industry Canada.

36. Dan Holt, 1995, ITS and Semiconductor Technology, Automotive Engineering .

37. Oliver Yandle, 1996, U.S. DOT Funds Development of ITS Standards, ITS Americal News.

38. Steven Hunt, 1996, GeoPost: Technology that's Street Smart, Technology Update. Performance.

39. Alan Vonderohe, On the Results of a Workshop on Generic Data Model for Linear Referencing Systems, GIS-T Reference Library.

40. Michael T. McNerney, 1995, Airport Pavement Management as part of an Integrated Airport Geographical Information System (GIS), ASCE Transportation Congress Proceedings, San Diego CA.

41. David G. McKellar, 1995, GIS Transfer Standardization: Case of Canada, Standards Council of Canada.

42. Jouko A. Parviainen, 1994, National Inventory of IVHS Programs and Related Activities in Canada- TP 11886 E, Transport Canada, Industry Canada and IVHS Canada.

43. Jerry Werner, Dave Davis, 1996, Inside San Antonio TransGuide, ITS Online.

44. Raley, MI, 1994, Toward more cost effective Transportation Planning: GIS Applications of Census Data and Tiger Line Files at Deldot, American Association of State Highways & Transportation.

45. Randy Doi, 1996, Approaches for Routing Emergency Notification Requests, ITS Architecture.

46. Raghu R. Kowshik, Prasuma Reddy, John Gard, Paul P. Jovanis, Ryuichi Kitamura, 1996, Real Time Rideshare Matching Using GIS, Paper Abstracts.

47. John Sutton, 1996, Integrating GIS_T and IVHS: Data Sharing for Dynamic Transportation Modeling, Paper Abstracts.

48. Dr. Muhammad Shahid Iqbal, Brian T. Ketcham, 1996, The Development of a Regional GIS-Transportation ITS/IVHS, Paper Abstracts.

49. IBI Group, 1996, ITS System Intergration and Intelligent Software, Industry Canada, Transport Canada.

Appendix B: Electronic Yellow Pages Technical Information

The data is divided into two different lots, Businesses and Consumers. Consumer lists are available in ASCII format and are * delimited. Each record is 219 bytes long and covers the following information.

Position	Content	Characters
1	Language Indicator (English or French E or F)	1
3 - 5	NPA (Area code)	3
6 - 13	Telephone Number	8
15 - 29	Title or Address (Mr., Mrs. Dr. etc.)	15
31 - 60	Subsequent word (initials or first name)	30
62 - 91	Finding Word (surname)	30
93 - 97	Title of status (Jr., Sr., Esp., Etc.)	5
99 - 103	House Number	5
105 - 107	House Suffix (A, ½)	3
109 - 138	Street name, type, direction	30
140 - 153	Location Type (Apartment, Townhouse, etc.)	14
155 - 160	Location number (Apt., Townhouse)	6
162 - 181	Community Name	20
183 - 184	Province (Ontario or Quebec)	7
194 - 219	Ranking or Ignore (If applicable)	25

Business lists are also available, and are ASCII delimited on 5 ¼ " or 3 ½ " diskette. The information is formatted as follows:

Position	
1 - 60	Name or Business
61 - 88	Street Address
89 - 105	Community Names
106 - 108	Province
109 - 114	Postal Code
115 - 117	NPA (Area Code)
118 - 124	Telephone Numbers
125 - 131	Heading Codes

132 Blank

There are several dealers within Canada that are resellers of this information. They along with Infodirect provide many other services that will assist one with integrating or enhancing this data for use in any application. Teledirect can offer Yellow Page data for all areas within Canada except British Columbia and Edmonton.

For further information please contact:

Infodirect - (416) 412-5366 or 1-800-361-3027 or

For British Columbia - Dominion List Services (604) 268-4597

For Edmonton - Contact Ed-Tel on the Internet http://www.edmonton.com

Appendix C: Advanced Public Transit Systems Map Database Specifications

DATABASE LAYER	SPECIFICATION LAYER	EXAMPLES
Transit Physical Layer	Spatial Feature	Bus Route 39, 59th Street Bridge barrier.
Transit Application layer	Included term	Bus stop, Fixed route, Bicycle Path
Transit Concept Layer	Spatial Feature	Access point, Segment, Transit Route
Geographic Layer	Spatial Object	**Five P's:** Point, Piece, Polygon, Path , Plane

Spatial Object Definitions and Default Attributes

POINT	PIECE	POLYGON	PATH	PLANE
A unit of location	A line connecting start, end and shape points	Two or more contiguous pieces with a common start and end point	One or more contiguous pieces	Topologically interrelated spatial elements
Representation of a point on a map, including geopolitical, address, intersection, coordinates, milepost, offset from start of piece.	Start Point End Point Shape point(s)	Collection of pieces Adjacent Polygons	Sequence of Pieces	Collection of component spatial elements Relationship of component spatial elements

Appendix D: GIS-T Map Data Suppliers & Industry Contacts

1.0 *Canadian Contacts*

For further information on Canadian Yellow Pages contact:

Infodirect - (416) 412-5366 or 1-800-361-3027 or

For British Columbia - Dominion List Services (604) 268-4597
For Edmonton - Contact Ed-Tel on the Internet http://www.edmonton.com

For further information on Canada Post Contact:

Philippe- Eric Landry
Canada Post Corporation
Address & Geopostal Management
2701 Riverside Drive, Suite N0950
Ottawa, Ontario K1A 0B1
Telephone: 613-734-3318

For further information on Compusearch contact:

Peter Baker
Compusearch Micromarketing Data & Systems
330 Front Street West, Suite 1100
Toronto, Ontario
M5V 3B7
Telephone: 416-348-9180
Fax: 416-348-9195

For further information on Navigation Technologies contact:

Kara Kelly
Navigation Technologies Canada
1315 Lawrence Avenue East, Suite 212
North York, Ontario
M3A 3R3
Telephone: 416-444-0980
Fax: 416-444-0710

For further information from Teranet contact:

Steve Rawlinson, Marketing Representative
1 Adelaide Street East, Suite 1405
Toronto, Ontario
M5C 2V9
Telephone: 1-416-360-5363
Fax: 1-416-360-0871

A dealer for the British Columbia TCN is Tetrad Computers, for more information contact:

Wilson Baker
Tetrad Computers
1445 West Georgia
Vancouver, British Columbia
Tel: 604-685-2295

For further information on Alberta GIS-T activities contact:

Eric Solmonsen
Alberta Transportation & Utilities
4999 98 Avenue
Edmonton, Alberta
T6B 2X3

Brian Klima
City of Lethbridge
910 - 4th Avenue South
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Janet Alyn
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Tel: 403-496-4092

John Lethaby
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For further on Saskatchewan GIS data information contact:

Mike Mepham
Central Surveys and Mapping
Province of Saskatchewan
2151 Scarth Street
Regina, Saskatchewan
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Tel: 306-787-2822

For further information on Manitoba GIS data call:

Grant Forsman
Manitoba Department of Highways
215 Garry Street, 12th Floor
Winnipeg, Manitoba
R3C 3Z1
Tel: 204-945-5151
Fax: 204-945-1608

or

Neil Aitken
Linnet Geomatics International
600 - 191 Broadway
Winnipeg, Manitoba
R3C 3T8
Tel: 204-957-7566
Fax: 204-957-7568

For more information on any Ontario programs please contact the following:

Ministry of Transportation Ontario
Brian Maloney
Surveys and Plans Office
1201 Wilson Avenue
Downsview, Ontario M3M 1J8

or

Colin Rayman
ITS Programs Office
1201 Wilson Avenue
Downsview, Ontario M3M 1J8

Ministry of Health
Barbara Bridgehouse
MacDonald Cartier Building
49 Place D'Armes, 3rd Floor
Kingston, Ontario K7L 5J3

Ministry of Natural Resources
Tom Malone
Information Resources Division
90 Sheppard Avenue East
5th Floor
North York, Ontario M2N 3A1

Region of Ottawa-Carleton
David Johnston
111 Lisgar Street
Ottawa-Carleton Center
Ottawa, Ontario K2P 2C7

For further information on Geomatics Canada contact:

Mike Sheppard
Geomatics Canada
615 Booth Street, Room 406
Ottawa, Canada
K1A 0E9
Tel: 613-947-1190
FAX: 613-995-6001

For further information on Transport Canada contact:

Arjan Chandan
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For further information on Elections Canada contact:

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For further information on IRD contact:

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For further information on M3i contact:

George Valade
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Suite 135, East Tower
Longueil, Quebec
J4K 5G4
Tel: 514-928-4600

For further information on Pulsearch contact:

James McLellan
6815E - 40th Street S.E
Calgary, Alberta
T2C 2W7
Tel: 403-720-0277

G.D Hamilton Associates Consulting

GD Hamilton provides research and analysis into effectiveness and applicability of advanced technologies in traffic engineering and transport planning. They have specific experience into the investigation of using GIS as a part of a motor vehicle collision system, and have developed an intelligent algorithm to identify correctable accident locations and suggest counter measures. For more information contact:

Frank Navin
9th Floor, 1199 West Hastings Street
Vancouver, British Columbia
V6E 3T5
Tel: 604-684-5908

Geoplan Consultants Inc.

Geoplan provides a wide range of services for Transportation Engineering, Surveys and Geographic Information Systems consulting. Geoplan has also been involved in a number of consulting engagements applying GIS technologies to Transportation applications. They have recently participated in the development of GIS-T standards with Transport Canada and the Transportation Association of Canada - TAC producing the final report " Geographic Information Standards for Transportation". Geoplan are also involved in a joint venture opportunity to develop advanced highway infrastructure inventory capture tools. For more information contact:

David Loukes
115 Prospect Street W
Fredericton, New Brunswick
E3B 2T7
Tel: 506-451-0055

For more information on Morrison-Hershfield contact:

Neil Standen
2440 Don Reid Drive , Suite 200
Ottawa, Ontario
K1H 8P5
Tel: 613-739-2910

For more information on GIRO contact:

Jean-Marc Rousseau
1100 Cremazie Blvd East, Suite 300
Montreal, Quebec
H2P 2X2
Tel: 514-383-0404

For further information on Computmap contact:

Dr. Godwill M Igwe
20 Glenvale Drive, #95
Hamilton, Ontario
L9C 5V4
Tel: 416-766-9588

2.0 *U.S. , European and Japanese Contacts*

DeLorme Mapping Company

DeLorme Mapping Company is located in Freeport, Maine and says it has become recognized as a pioneer in the field of geographic information management and mapping product development. Established almost 20 years ago, DeLorme Mapping began as a paper map publisher providing thematic maps of Maine and other states around the USA. These maps evolved into the DeLorme State Atlas and Gazetteer series.

As computers become more powerful and affordable, DeLorme produced the first World Atlas on a single D-ROM. This digital mapping technology developed into a family of products which provide users with maps, imagery, and evaluation data, linked to databases of latitude/longitude, placenames, phone numbers, zip codes, and other key information. Several patents have been registered for what DeLorme says is unique, high-speed digital data storage and display technology.

DeLorme's success in the consumer marketplace for products operating on personal computers has led to corporate growth and investment in R&D of new technology. Recent accomplishments include CD-ROM products, Street Atlas USA® and Map'n'Go™. While still classified as a small business, it currently employs about 160 trained geographers, cartographers, imagery scientists, computer programmers, systems analysts, and other professionals involved with development of new products and technology for the consumer marketplace.

ITS Products & Systems

- Digital map display systems
- Global positioning system (GPS) navigation systems
- Vehicle tracking systems
- Database development

For further information Contact:

Gordon Autry, director of business development
P.O. Box 298, Lower Main Street
Freeport, Maine 04032
USA
Telephone: 207-865-4171
webmaster@delorme.com
Internet WWW address: http://www.delorme.com

Geographic Data Technology, Inc. (GDT)

Geographic Data Technology was founded in 1980 by Donald Cooke, who had worked on the development of the DIME file while at the U.S. Census Bureau, and realized its potential as the basis for a geographical database for the entire U.S. GDT's first product was an enhanced version of the 1970 Urban Atlas Census Tract. Following the development of the TIGER files at the Census Bureau, GDT began enhancing these files, and the resulting product was Dynamap/2000. GDT's Highways product, which is derived from its master cartographic database, combines TIGER/Line Files with postal data from the U.S. Postal Service, and is designed for developers of road mapping applications.

GDT says that its goal is to provide the most accurate and up-to-date geographic data for use in desktop mapping systems, Geographic Information Systems (GIS), and automated mapping. The company says that is the leading provider of geographic data to the GIS industry. GDT also provides address geocoding services and software, and custom geographic databases to meet the specific needs of its customers.

ITS Products & Systems

- Geocoding software: Matchmaker/2000® for Windows, a nationwide geocoding software, attaches latitude/longitude coordinates and census codes to address lists. Geocoded addresses can be analyzed, grouped, and displayed with any desktop mapping or geographic information systems (GIS) application.
- GDT's nationwide street databases:

    * Dynamap/2000 includes over 13.5 million addressed segments, improved street classification codes, logical layering for hydrology and landmarks, 5-digit Zip code boundaries, census tracts, block groups, and the Dynamap/2000 Geocoder for nationwide address matching to latitude/longitude coordinates and Zip+4's.

    * Dynamap/1000 is a fully realigned nationwide street database which contains address information, census tract, county boundaries, water, landmark and point layers, and the Dynamap/1000 Geocoder for nationwide latitude/longitude address matching on a single CD.

Nationwide Dynamap boundary and inventory products: include 5-digit Zip codes, Zip+2, Zip+4, county, minor civil division/census tracts, census block groups, census blocks, designated market area (DMA) and metropolitan statistical area (MSA).

Formats are ARC/INFO®, ArcView® v.2, MapInfo®, AtlasGIS™, Tactician®, SAS/GIS™, MGE

For further information contact:

Molly Hutchins, Marketing Manager
11 Lafayette Street
Lebanon, New Hampshire 03766-1445
USA
Telephone: 603-643-0330

Geospan Corporation

Geospan was formed in 1990 to provide leading-edge Visual Geographic Information (VGI)™. The company is establishing data collection business partners in 38 territories throughout the U.S. to collect and distribute GeoVista data. Two data collection business partners are operational (Los Angeles and Minneapolis/St/ Paul). The remaining 36 territories are scheduled to be operational by 1996.

ITS Products & Systems

Geospan is using Global Positioning System (GPS), Inertial Navigation Systems (IRS) and on-board mapping systems in video-equipped data collection vehicles called GeoVans to create accurate and reliable GeoVista databases of U.S. streets for ITS applications. The GeoVista databases contain street centerlines positioned within one meter accuracy, verifiable vehicle routing data (such as speed limits, turn restrictions, one-way streets, traffic signals, road classifications, number of lanes), and actual images (video and pictures) of the streets and surrounding infrastructure and real estate.

Other primary products & servers

- Images (actual video and pictures) of streets and their accompanying infrastructures and real estate
- Accurate electronic street maps with accurate street addresses
- Vehicle routing packages
- Street address packages

Ted Lachinski, President
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GeoSystems

GeoSystems, a wholly-owned subsidiary of R.R. Donnelley & Sons Company, provides specialized application-focused software, digital mapping and product development services to the travel, telecommunications (Yellow Pages and cellular), transit, publishing and general commercial markets. GeoSystems provides locational software, database development and system integration services for an array of delivery technologies. GeoSystems business is focused on projects that require the integration of digital maps with travel, Yellow Pages and business information together with embedded Geographic Information System (GIS) software tools for quick and intuitive map display, locating and routing.

GeoSystems has a blend of digital cartographic production services (employing Arc/Info and Macintosh-based tools); database integration services; application development services and consumer product development services. It provides value-added services which leverage third party digital map databases, in addition to its own digital U.S. Atlas (1:2,000,000) and specialized cartographic data products.

GeoLocate® technology is embedded in the applications that it creates for its customers which support the query, display and routing of geographic databases. GeoSystems says that this combination provides its customers with intuitive and focused applications for enhancing their products and services with geographic-referenced information and GIS software.

GeoSystems was created in 1991 as the sister company to the Donnelley Cartographic Services business founded in 1967. In 1993, GeoSystems and Cartographic Services merged to provide a combination of geographic information technology and digital mapping services.

ITS Products & Systems

- GeoLocate®: core mapping, locating and directional software that can be customized for use in kiosks, on-line systems, directories, commercial and consumer applications
- Voyager®: an automated, cross-country travel planning system that can provide instantaneous, comprehensive route maps complete with narrative travel directions, mileage's and travel times, as well as locations and descriptions of facilities, points of interest and landmarks along the way.
- Custom Cartography: maps for textbooks, telephone directories, encyclopedias, atlases, specialized scholarly works, travel publications, animated maps for CD-ROM-based products, marketing and promotional materials

ITS Strategic Alliances / Clients

The companies GeoSystems works with include:

- Apple Computer Inc. (Newton™ PDA)
- NYNEX
- Compton's NewMedia
- American Automobile Association (AAA)
- OAG
- Galileo International (Apollo Airline CRS)
- Ameritech
- The National Geographic Society
- Avis
- Grolier

Number of ITS-dedicated Staff

The technical staff is comprised of approximately 40 digital cartographers, 35 application software specialists and 35 database integration specialists.

Barry Glick, president & CEO
227 Granite Run Drive
Lancaster, Pennsylvania 17601
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MapInfo

Mapinfo is the supplier of the product MapInfo, a Geographic Information System (GIS) package for DOS, Windows and the Macintosh operating systems. Some of it's subcomponents are:

- Maps&Data, a Windows mapping package including maps ranging from world view to Zip Code level
- MapBasic, a programming tools designed to allow the customization of MapInfo to create vertical market applications
- StreetInfo digital database including streets/names, highways/names, town boundaries and address ranges for all U.S. counties, also available on CD-ROM
- Canadian StreetInfo and Highway Map
- U.S. Highway Map

- New York City Premium Map
- Mexican Highway Map

For further information contact:

Randy Drawas, vice president of marketing
One Global view
Troy, New York 12180
USA
Telephone: 518-285-6000

Roadnet Technologies , Inc.

Roadnet Technologies, Inc. is a division of UPS Worldwide Logistics, and first developed its proprietary digital street map databases to support its Roadnet vehicle routing and scheduling product. In 1992, Roadnet began to make its digital mapping products available for purchase separate from the routing product. Although the sources for most of Roadnet's mapping products are public agencies such as the Geological Survey and Census Bureau, UPS/Roadnet local field verification teams assist in gathering, updating and verifying the company's national map database.

- Roadnet Highway Plus: digital street map database containing all major roads for the United States as well as detailed streets in most major metropolitan areas. Digitized at a scale of 1:24,000, Highway Plus contains more than 700,000 segments representing approximately 602,000 miles of roads. Since the original purpose of the data was for routing and networking vehicles, topology has bee built within each state and features have been edge matched along state boundaries to provide continuous highway coverage between states.
- Roadnet City Streets: Enhanced TIGER (Topologically Integrated Geographic Encoding and Referencing) '92 information containing all roads with accurate road classifications, address range information, zip codes, political boundaries and more. This database offers increases address coverage and new street information gained from United Parcel Service (UPS) operating centers.
- Roadnet 5000: a PC-based software system that computes least-cost routes and is a tool for management control. It creates routing and scheduling assignments considering criteria such as the number of vehicles, vehicle types, variable driver starting times, preferred and maximum route duration, time window requirements, multiple depots and more. Full colour plots can also be displayed on detailed digital maps.
- Territory Planner: a PC-based routing and scheduling system designed for the route sales environment. It uses advanced algorithmic software to design balance and geographically cluster territories, routes and route sequences.
- Load manager: a PC-based system designed to streamline loading operations for beverage distributors. Variables such as truck and by capacities, loading preferences, loading order and bay location are established by the user and considered in the load configuration.
- Route Service: a service for companies that would like to receive the benefits of the above mentioned routing systems without purchasing and installing a system.

ITS Strategic Alliances / Clients

Exchanging technology for data, Roadnet actively develops partnerships with government and industry entities interested in benefiting from its Geographic Information System (GIS) development experience.

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Spatial Data Sciences, Inc.

Spatial Data Sciences, Inc. is a software development company incorporated in 1987 which a specialty in geographic analysis, map production software, and automated routing algorithms. The company says it was the first to introduce a graphical map-based routing package for automobile travel clubs and that over 500,000 trip plans were produced for club member in 1994. Other products include TIGER-based redistricting and demographic analysis software and map printing packages.

For further information contact:

Dr. John Turner
8200 Greensboro Drive, Suite 1020
McLean, Virginia 22102
USA
Telephone: 703-893-0183

ITS Products & Systems

- CustomMaps™: Trip routing automated map production with route highlights and narrative directions.
- MapStation™: Windows map display system for vehicle tracking
- North American Geographic Database: Political, hydro, road network data for US, Canada, and Mexico
- North American Transportation Network (NATN): proprietary digital transportation model

ITS Clients

- In 1994, Spatial Data Sciences delivered the computer routing system for colour laser printer of the American Automobile Association (AAA) Triptik product.
- The NATN is resold or embedded by a number of larger companies, including Drivetime, Inc., MapInfo, Tactician, GeoSystems, EDS, and Cummins Cash
- MapStation is incorporated by several GPS systems integrators for fleet management and vehicle tracking.

Automobile Association - AA

The AA is a motoring organization that has 8.3 million members in the U.K. It offers roadside breakdown services, technical, touring and legal advice to its members. As a traffic information and digital road map database provider, the AA publishes travel, mapping and touring information in paper, magnetic, CD-ROM and on-line formats. The AA acts to promote its members' interests in debates over road pricing, tolling and driver information.

Ralph Robbins, mapping
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Basingstoke
Hampshire

U.S. - RG24 9NY
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Telephone: 44 1256 492906

ITS Technologies/Services

- Roadwatch: traffic and travel information (road, rail, bus) broadcasting service for the United Kingdom. Information from nine regional Roadwatch centers. Police forces, car phone callers, local authorities and AA patrols is sent to a national database that produces approximately 300,000 traffic congestion and weather bulletins a year. These bulletins are sent by radio, teletext, audiotext, cable/satellite television, on-line services such as Tel-Me, Compuserve, public information terminals (Comunik 8) and print.
- Automaps: digital map provider for GIS (Geographic Information System) and transport telematics use.
- RDS-TMC (Radio Data System-Traffic Message Channel) location coding. Responsible for U.K. RDS-TMC codes for the U.K. Department of transport. Supplier of location codes for three DRVIE II projects.
- Routes: text-based route, time and mileage system for U.K., Ireland and Europe.

ITS Project Participation

- EC-funded Fourth Framework program project proposals:
  - EUROSCOPE (Efficient Urban Transport Operation Services Cooperation Of Port Cities in EU)
  - FORCE (Enhanced field projects for large scale introduction and validation of RDS-TMC)
  - TABASCO (Telematics Applications on Bavaria and Scotland)
- TITAN travel planner for Ireland on CD-ROM
- AUTOCAT (Automatic road traffic attribute collection)
- ERIC (European Road Information Center) member
- EGT (European Geographic Technologies) shareholder
- DRIVE II projects:
  - PLEIADES (Paris London corridor)
  - INTERCHANGE (European traveler information network)
  - ATT ALERT (Advanced transport telematics-advice and problem location for European road traffic)
  - GEMINI (Generation of event messages in the new integrated road transport environment)
  - PROMISE (Prometheus mobile and portable information systems in Europe)
- PROMETHEUS project EUROFLEETMAN which plans to offer automatic vehicle location and tracking to commercial fleet operators in Europe.

AND Mapping

AND Mapping BV has been developing map databases since 1989. Software, running on DOS and UNIX, is available for database editing and interrogation. AND Road map databases are used for vehicle route planning, site location, marketing, tracking and paper map production.

ITS Technologies/Services

Digital road mapping and client-specific database provision A European map database, excluding Iceland and CIS (Commonwealth of Independent States), is available at scale 1:500,000

World-wide digital road map at an average scale of 1:1,500,000. Database covers Africa, America, Australia, Russia and Europe.

European countries have been mapped at the following scales

- 1:200,000:
  - Spain
- 1:250,000:
  - The Netherlands
  - France
  - Denmark
  - Germany
  - Ireland
- 1:300,000:
  - Austria
  - Belgium
  - Italy
  - Sweden
  - United Kingdom
  - Greece
  - Turkey

ITS Project Participation

- GENIGIS project within Eureka (European Research coordination Agency) initiative. Generating unique data structures optimized for geographic information systems.
- Kuwait Mobile Telecommunications Company vehicle location system, AND Mapping is providing a digital street map of Kuwait at a scale of 1:50,000 refined through Global Positioning System (GPS) to 1:10,000. Communications between vehicles and control center is provided by GSM (Global System for Mobile communications) digital cellular radio.

For further information contact:

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Geometria GIS Systems House

Geometria GIS Systems House has been involved in the GIS field since 1986. The company employs over 100 people.

ITS Technologies/Services

Geometria convert maps into digital databases for use in vehicle navigation systems
GIS (Geographic information system) software development

ITS Project Participation

Converting German, French and Italian road map database into a digital database at scale 1:25,000 for navigation applications

Digital road network covering Austria at scale 1:200,000, in cooperation with AGIS GmbH.

Strategic Alliances & Joint Ventures

EGT (European Geographic Technologies), the Netherlands

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Grafinta

Grafinta SA is specialized in surveying, mapping, Photogrammetry, hydrography and remote sensing. The company has alliances with Pentax, Japan; Trimble, International Imaging Systems. Odom and Coastal Oceangraphic, U.S.

ITS Technologies/Services

- BACARES (Base Cartografica de Espana) analog map database of Spain. Continuously updated. Supplied for use in vehicle positioning and tracking systems

ITS Project Participation

- Joint venture with Formatek, Quebec, Canada

For further information contact:

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Spain
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Graphic Data Systems

Graphic Data Systems, U.K. is a subsidiary of GDS Corporation of Colorado, U.S. GDS is an affiliate of the Convergent Group. Other affiliates are EDS and UGC Consulting. Key services are GIS, AM/FM (Automated Mapping/Facilities Management) and CADD (Computer-Aided Design and Drafting).

ITS Technologies/Services

GDS (Graphic Data System) object referenced graphic database for use in digital map database management, topological data modeling, geographic information systems and application development.

GDS can be used in DEC, HP, SUN Unix and Windows environments

Route builder route permit management package

Geographic Information System (GIS) software for use within applications such as:

* Advanced Traffic Management System (ATMS)
* Public transport information systems
* Incident management systems
* Routing systems
* Access control and permit routing

ITS Project Participation

London Transport information system

Dallas area rapid transit information system

New Jersey Turnpike Authority incident management system

Los Angeles Earthquake Planning and Implementation Center. Supplying the graphic display system for the traffic management facility.

For further information contact:

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Intergraph

Intergraph produces geographic information products used in road and pavement maintenance management, emergency vehicle dispatch and routing, and network analysis. The company was founded in 1969.

ITS Technologies/Services

Digital mapping and geographic information software products

- GDF (Geographic Data File)
- GIS (Geographic Information System)

ITS Project Participation

- DRIVE II project EDRM II (European Digital Road Map)
- TITAN (Travel Information and Tourist Assistance Network) project, part of the EC's IMPACT II (Information Market Policy Actions) program

Strategic Alliances & Joint Ventures

TITAN partners:

- Automobile Association, U.K.
- MVA Systematica, U.K.

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or

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Planungsburo Transport und Verkehr GmbH - PTV

The PTV group has a staff of 150. Customized system design and implementation is offered in DOS, WINDOWS and UNIX environments. PTV specializes in software design and system development in the logistics field.

ITS Technologies/Services

- INTERTOUR software route planning system designed for multi-drop pickup and delivery routes. Installed at 140 firms in central Europe.
- INTERLOAD planning software for long range haulage including Multimodal transport.
- IKONA digital gazetteer providing post codes, location names and coordinates for all European countries
- NETZ digitized road networks of Europe
- MAP & GUIDE Windows-based GIS (Geographic Information System) software with routing applications
- TRAVELBOOK Windows-based route guidance system

ITS Project Participation

- EC-funded Fourth Framework program project proposals:
  - SURFF (Sustainable Urban and Regional Freight Flows)
  - WELCOM (West-East Logistics Corridor for Multi modal transport)
- DRIVE II project MITHOS (Monitoring Intermodal Transport of Hazardous goods)

For further information contact:

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Tele Atlas

Tele Atlas was reorganized in 1995. EDRA (European Digital Road Map Association), which contained Tele Atlas, Bosch and Etak, was disbanded. Bosch and Janivo Holdings (the owners of Tele Atlas) created a joint venture company called Tele Atlas. The company aims to provide navigable digital road maps for all western Europe by 1997. The holding company of Tele Atlas is located in 's Hertogenbosch, the Netherlands. The research, production and marketing functions are performed in the head office in Gent, Belgium. Tele Atlas provided Flat with Italian city map databases for its VENUS in-vehicle navigation system prototype. Tele Atlas maps are also used in the Blaupunkt Travelpilot in-vehicle navigation system developed by Bosch and in the Mercedes-Benz Auto Pilot product. The company claims to have completed mapping of Germany, Belgium, the Netherlands, Luxembourg, northern Italy and Paris. Completion of Italy, Austria, Switzerland and France is due by 1996. Spain, Protugal and Scandinvavia should be complete by 1997. Etak has responsibility for the U.K.

ITS Technologies/Services

- Pan-European navigable digital road maps for application in:
  - Route guidance and in-vehicle navigation systems
  - Fleet management
  - Information terminals
  - Dispatching centers
- Map digitizing software and hardware (IBM PS/2 PCs and CalComp digitizers)
- Database production, management and updating

ITS Project Participation

- IMPACT (Information market policy actions) European commission directorate general XIII project VITAL (Visitors Information on transport and locations)
- ISO (International Standards Organization) technical committee TC 204 convenor of sub-working group 3.1 GDF (Geographic Data File).
- CEN (Comite') Europeen de Normalisation) TC 278 (road transport telematics) member.
- DRIVE II project EDRM (European digital road map) developing GDF (Geographic Data Files)

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Nichimen Corporation

Nichimen Corporation is acting as the Japanese agent for U.S.-based Navigation Technologies (NavTech) and European Geographic Technologies (EGT) of the Netherlands. NavTech and EGT are digital road map database suppliers. Nichimen is a NavTech shareholder.

For further information contact:

Makoto Tojo, Navigation Project Electronics
For further information contact:
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Tokyo 103
Japan
Telephone: 81 3 3277 5046

Zenrin

The Zenrin Navisoft digital map database of Japan was used in the VNS (Voice Navigation System) fitted to the Celsior (Lexus) car model from Toyota. The Naviken format developed by Zenrin is used in navigation systems produced by 14 manufacturers in Japan. The database is based on a scale of !:25,000 and covers all roads in Japan with a width of over 3 meters. Site surveys were performed at 180,000 intersections to ensure junction accuracy. Zenrin is investigating the inclusion of dynamic travel information into map databases from VICS and ATIS. A three dimensional map display is being researched by Zenrin.

ITS Technologies/Services

- Navisoft CD-ROM (Compact Disk-Read Only Memory) digital road map of Japan. Navisoft incorporates the Naviken format standard agreed by the NRA. The digital map database was developed in collaboration with:

    * Aisin Aw

    * Equos Research

    * Toyota

ITS Project Participation

- ISO (International Standards Organization) technical committee 204 (transport information and control systems)
- NRA (Navigation System Research Association) cofounder
- ATIS (Advanced Traffic Information Service)
- VICS (Vehicle Information and Communication System)
- UTMS (Universal Traffic Management Society)

For further information contact:

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Kitakyushu 804
Japan
Telephone: 81 93 883 5207

AutoTrac sells both the hardware and the software to be able to manage a complete commercial fleet via a map based system.

For more information contact:
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Auto-Trac
6250 LBJ Freeway, Suite 201
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For further information on ETAK contact:

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For further information on JDRMA contact:

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For further information on EGT contact:

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For further information on FHWA contact:

US Department of Transportation
Bureau of Transportation Statistics
400 7th Street SW, Room 2104
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202-366-DATA

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Appendix D: Detailed Map Related Requirements for APTS

Demand Responsive Public Transportation

Within the demand responsive side of Public transportation, the following functions can be enhanced by the use of GIS-T technologies:

Provide customer information

Estimate fare based on Distance / Route
    Criteria - Time of day, Passenger fare, subsidies, pickup and drop-off points.
Compute fare
    Time-since-pickup, distance-since-pickup, Inputs to estimate fare, subsidies
Estimate time until pickup
    Contact customer if constraints not met

Process a reservation (Obtain passenger - specific information)

Make a reservation
    Verify pickup and drop-off points (i.e. find them in the GIS)
Dispatch a vehicle

Pick-up Drop-off a passenger

verify identification
update vehicle status

Maintain vehicle status database

Query vehicle status
receive vehicle status

Update vehicle route

Monitor performance

Fixed Route Operations

Functions

Assign Vehicles and Drivers Daily
Dispatch Vehicles
Pick-up and Drop Off passengers
Deadhead

Managing Service

Data Collection
  Vehicle Position
  Schedule Adherence
  Route adherence
  Headway Adherence
  Passenger data
  Status of vehicle components
  Traffic and weather conditions

Calculation and Analysis
Vehicle performance loading
Driver preference
Schedule/route/headway adherence
Estimated time of arrival at a specific point or stop
Passenger statistics
System wide statistics

Service Restoration

Dispatch vehicle to replace disable vehicle
Restore vehicle schedule through rerouting
Adjust vehicle schedule
Perform adaptive signal control

Transfers and Connections

GIS-T can help by coordinating the routes of adjoining vehicles depending on route and stop dependencies. Often timing of the adjoining routes need to be rescheduled to meet links between routes.

Analysis and Planning

Service Planning
Supply
- Route
- Vehicle
- Access Points

Demand
- Multimodal Network
- Trip
- Trip Maker

Performance Analysis
Supply
- Run
- Vehicle
- Operator
- Other assets/facilities

Demand
- Boarding
- alighting
- trip length
- Fare payment

Results - Special needs vehicles, routes, HOV lanes, regulatory compliance, corridor studies.

Transit service planning

Market Analysis
Who will use services
market programs for new riders
Customer satisfaction

Transit Operations Planning

peak period
# of vehicles
Bigger buses vs. small

Transit Service Planning
New routes
Origin & destination
special needs users
changes in infrastructure

Customer Information
anyone who needs information about the system

User Information Systems
fares and Map distribution
fare collection
Traveler route generation
Special Services availability (ADA)
Additional Services (ATM ticketing, reservation, local information)

User Acquisition Systems
On-line public vs. private comparison

MIS
Reporting

Worker Information system
Schedule assignment reporting
Vehicle and Run data gathering

Technologies
Kiosk
Internet
Public vehicle display
MDT's
Hand held devices

Safety and Security
Emergency dispatch

Requirements

Fixed Route Operations - Provide Service , Service Monitoring
Open and flexible- easily add features and attributes.

Appendix E: Mapping Requirements for Computer Aided Dispatch

- Have the ability to import mapping data and related tabular information. The system should have the ability to add or modify this data.
- The system must be able to display all Emergency vehicles and their status with sufficient accuracy that the display will coincide with a specified single line street network.

The mapping must use the following information to be able to perform its routing options:

- Single Line Street Network
- Street Direction
- Private Road
- Road Built Status
- Dual lane Roads
- Cloverleaf Interchanges
- Bridges, Overpasses, & Underpasses
- Divided roadway attribute, specifically barriers to crossing
- Intersections
- 100 block
- Bus only crossing/vehicle trap
- HOV lanes
- Road closure
- Bike Paths and Walkways
- Turning lanes

- have the ability to integrate other mapping or aerial photography information as a reference backdrop.

Must be able to integrate other information for the future like:

- Brick paths & walkways
- Speed limit Data
- Traffic Flow data
- Traffic control Zones
- Stop Signs, Traffic Lights